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THE GEOLOGY OF AUSTRALIA

1. **GENERAL** - The geology of different parts of Australia has, naturally. been studied with varying degrees of thoroughness. The great area to be covered, the difficulties to be encountered, and the limited time so far available, are obvious. Instead of attempting. therefore, to present in bold outline a general picture of Australian Geology, it is proposed to give authoritative, independent sketches of the geology of each State, notwithstanding that this will necessarily involve some degree of repetition.

A knowledge of the main features of Australian physical geography will be assumed, and references thereto consequently reduced to a minimum.

2. **GEOLOGY OF NEW SOUTH WALES**[1] - In physical configuration New South Wales may be divided into three regions viz - (1) The narrow coastal plain on the east; (2) the Great Dividing Range and its associated table-lands; and (3) the western plains. These will first be individually referred to.

(i.) The Main Dividinq Range. The main dividing range or table-land of New South Wales is composed for the main part of Palœozoic sediments, together with granitic and other igneous rocks; that portion of it, however, which is situated to the westward of Maitland. Sydney. and Wollongong, is capped, with Mesozoic strata. viz., the Hawkesbury series, forming the covering of the principal coal basin.

(ii) The Coastal Plains. The coastal plains, which extend from the eastern foothills of the Dividing Range to the ocean, and which vary in width from a mile or two up to 150 miles, contain two coal-bearing basins, the chief of which extends from the neighbourhood of Maitland on the north to the Shoalhaven River on the south. This coal basin consists of the Permo-Carboniferous coal measures overlaid by the Hawkesbury (Triassic) series. The second coal-field referred to is that known as the Clarence and Richmond field. It is composed of Triassic or Trias-Jura rocks, and so far as at present known it contains no coal seams of commercial value. It may, however, he underlain by the productive Permo-Carboniferous measures.

The coastal plains are also largely composed of Post-Tertiary fluviatile deposits, which form exceedingly rich agricultura1 areas. A considerable area between the Richmond and the Tweed Rivers is occupied by basalt, the decomposition of which has produced a rich soil eminently suitable for agriculture and dairy farming.

(iii.) The Great Western Plains. The great western plains, which extend from the western foothills of the great tableland, are underlain by granitic rocks and sediments of Palœozoic, Mesozoic, and early Tertiary age. The most northerly portion is Mesozoic (Triassic), and forms the artesian water-basin. South of this is a Palœozoic belt stretching westerly from the great tableland to the South Australian border. During the Mesozoic era this belt formed a mountain range, whose direction was at right angles to the main divide; but this range was subsequently planed down by denudation, and its surface is now level with the surrounding country. To the south of this, along the Lower Darling and the Murray, is a large area of early Tertiary marine beds (Eocene), while the remainder of the Riverina district (up the Murray. Murrumbidgee, and Lachlan Rivers) is underlain for the most part by granitic, Silurian, and Devonian rocks.

The surface of the western plains is covered by Post-Tertiary deposits, flood loams, etc., except in isolated places where the remains of the older formations still rise above their surface.

(iv.) Classification of the Sedimentary Rocks of New South Wales. In the following classification some indication of the economic significance of the different members of each series is given:

CAINOZOIC.	Post-Tertiary.	Recent; auriferous and stanniferous soils and alluvial deposits in the beds of existing rivers Pleistocene; alluvial leads containing gold,tin and gem-stones	
	Tertiary.	Pliocene; alluvial leads, frequently covered by basalt, and containing gold,tin and gen-stones. Miocene; quartzite with plant remains at Dalton, near Gunning.Eocene; marine limestone and calcareous sandstone of the Lower Darling; plant beds of the New England district.	
MESOZOIC.	Cretaceous.	Upper Cretaceous (desert sandstone); contains deposits of precious opal. Middle Cretaceous; auriferous alluvial leads at Mount Brown. Lower Cretaceous (Rolling Downs formation of Queensland).	
	Jurassic.	Talbragar fish bearing shales.	
	Triassic.	The Ipswich coal measures and the Clarence coal measures.	Form the base of the artesian water-bearing basin. These measures contain thin coal seams, not at present worked in New South Wales.
		Hawkesbury series.	Wiannamatta shales (contain fire-clays).Hawkesbury sandstones (building

			stone).Narrabeen shale.
PALAEOZOIC	Permo-Carboniferous	1. Upper or Newcastlecoal measures 2. Dempsey series 3. Middle or Tomago coal measures 4. Upper marine series 5. Greta coal measures 6. Lower marine series	The productive coal seams of New South Wales occur in these measures
	Carboniferous	Rhacopteris beds and associated marine beds Gympie claystones (of Queensland)	All the metalliferous lodes and reefs occur in these forations, or in such igneus rocks as granites, quartz-porphyries, felsites, diorites, etc
	Devonian	Upper Devonian. Lower Devonian.	
	Silurian	Limestones and slates at Yass, Molong Wellington, Quidong, etc	
	Ordovician	Slates and tuffs at Mandurama, Cadia, Tomingley, Berridale, and in the countries of Auckland and Wellesley, on the Victorian border	
	Cambrian	Limestones, schists and glacial beds of Terrawingee	

(v) **Cambrian System**. The oldest sedimentary rocks of New South Wales are probably those forming the Barrier Ranges in the far west. No organic remains have yet been found in them, and their geological age has been a matter of speculation for many years. Quite recently Mr. Mawson, of Adelaide, has stated that he has traced the Lower Cambrian beds of South Australia to Terrawingee, north of Broken Hill, and he also considers that the metamorphic rocks of Broken Hill may be of pro-Cambrian age. These statements have not yet been confirmed by the New South Wales Geological Survey, though it is quite possible they are correct.

The rocks at Broken Hill consist of a laminated series of crystalline gneisses, quartzites, micaceous and hornblendic schists, and garnet sandstones. Broken Hill itself is a low range in which these rocks have been folded into an anticline. The great Broken Hill lode occupies the saddle-shaped cavity caused by the folding of the strata as stated, but the saddle lode is now of

larger dimensions than the original cavity, owing to the gradual replacement (metasomatism) of the country rock forming the walls by ores of lead, silver, and zinc.

To the north of Broken Hill the metamorphic rocks just described give place - in an unbroken series - to less altered slates and schists. traversed by tin-bearing dykes of coarse pegmatite, as at Euriowie, while at Terrawingee there are massive beds of blue Limestone (and, according to Mr. Mawson, glacial till), which apparently belong to the same series.

(vi.) **Ordovician System**. At the Lyndhurst goldfields, near Mandurama, occurs a series of banded sedimentary rocks, consisting of indurated bluish grey claystones alternating with highly altered volcanic tufts. The claystones contain Trilobites (agnostidœ), Brachiopods (obohella), Pteropods (hyolithes). Graptolites (diplograptus, dicellograptus, chimacograptus, etc.). amid remains of Radiolaria. The tuff beds, which vary from the thickness of paper up to 20 feet, contain bunches and impregnations of auriferous sulphides, and are worked for gold.

The series of banded rocks has been intruded by sills and dykes of hornblende. andesite, etc., which are apparently offshoots from a large body of hornblendic granite. The intrusions appear to have occurred while the sediments were still in a plastic condition, for the tufts have been so forced into the claystones as to give the former the appearance of being intrusive.

Dark blue claystones and slates containing similar Graptolites also occur at Tomningley, Cadia. Berridale, and on the Victorian border - counties of Auckland and Wellesley. At Tomingley the slates are intersected by auriferous quartz reefs.

(vii) **Silurian System**. Silurian rocks cover a large area of New South Wales, but the locality where they can be most satisfactorily studied is between Yass and the Murrumbidgee River. There they consist of a considerable thickness of slates, sandstones, and limestones, with numerous characteristic fossils, such as Trilobites, Corals, Echinoderms, Brachiopoda. and Mollusca.

The celebrated auriferous reefs at Hill End, Tambaroora, and Hargraves occur in Silurian rocks, consisting of slates with interhedded volcanic tufts, the latter being fossiliferous at Hill End. The Silurian rocks have been intruded, altered, and disturbed by granites, felspar porphyries, etc.

(viii.) **The Devonian System**. The Silurian slates and limestones to the south of Yass are succeeded by a belt of lavas (rhyolites, etc.) arid tufis, which separate them from a newer series of blue limestones, quartzites, and slates containing fossils of Lower Devonian affinities. At Wellington also the junction can be seen between Silurian and Lower Devonian rocks. At Tamworth, rocks of the same age as the Carboniferous of Europe are underlain by a series of banded claystone and volcanic tufts, with occasional beds of limestone and intrusive sills of granite. The claystones contain numerous Radiolarian remains, while in the tuffs is found the plant Lepidodendron. australe, and the limestones contain an abundant fossil fauna, including corals, which enable these beds to be correlated with the Upper Devonian of Queensland. A good section of Upper Devonian quartzites and shales containing Lepidodendron australe and numerous marine fossils can also be seen at Mount Lambie, near Rydal.

The Devonian system is characterised by the prevalence of grey and red quartzites md grits, and vary large areas of the southern half of the State arc covered by these rocks.

(ix.) **The Carboniferous System**. A considerable area of the coastal plain and tableland north of Newcastle is occupied by bluish claystones and tufts, with occasional belts of limestones, corresponding in age with the Lower Carboniferous rocks of Europe. Near Port Stephens they contain interbedded deposits of Magnetite, which, however, contains a considerable percentage of Titanium, whereby its value as an iron ore is reduced. At Copeland and several other goldfields the claystones are intersected by gold-bearing reefs. The plant Lepidodendron australe

is fairly common in Lower Carboniferous rocks as well as in the Upper Devonian.

In the neighbourhood of Stroud is an area of shales, sandstones, and cherts containing abundant impressions of Rhacopteris, and these beds have been classified as Upper Carboniferous. No workable seams of coal have been found in the Carboniferous system, though in the Rhacopteris series near Stroud several very inferior seams with numerous bands are known.

(x.) **The Permo-Carboniferous System**. The productive coal measures of New South Wales contain fossil remains, shewing affinities to both the Permian and Carboniferous systems of Europe, hence the composite name which has been given to them. The measures are about 15,000 feet in thickness and have been classified as follows: -

(a) Upper or Newcastle Coal Measures, containing an aggregate of about 100 feet of coal.

(b) Dempsey Series: freshwater beds containing no productive coal. This series thins out completely in certain directions.

(c) Middle, or Tomago, or East Maitland Coal Measures, containing an aggregate of about 40 feet of coal.

(d) Upper Marine Series; sandstones and shales specially characterised by the predominance of the brachiopod Productus brachythœtus. At Braniton traces of glacial action have been found in these beds.

(e) Lower, or Greta Coal Measures, containing front 20 to 40 feet of coal.

(f) Lower Marine Series; sandstones and shales: specially characterised by the molluse Eurydesma cordata. Glaciated boulders and erratics have been found in these beds at Lochinvar.

The three coal-bearing series contain numerous plant remains, including Glossopteris, Gangamopteris, Phyllotheca, Nagqerathopsis, etc., while the Lower and Upper Marine series are characterised by an abundant fauna. The Permo-Carboniferous coal basin occupies an area of about 25,000 square miles extending to the north, west, and south of Sydney. and is the storehouse of one of the States most valuable assets. ln several collieries near West Maitland very fine seams of coal of 20 feet and upwards are being worked. A narrow isolated deposit of the Permo-Carboniferous system extends from near Inverell to the Queensland border. It contains a fine seam of coal (27 feet thick in places), which probably belongs to the Greta series. These measures lie unconformably upon altered claystones of Lower Carboniferous age, and have been intruded by granite which has tilted the coal seam to an angle of about 40 degrees.

(xi.) *T***he Triassic System**. The Permo-Carboniferous coal basin is overlain in most places by a thickness of over 1000 feet of shales and thick-bedded sandstones There is no apparent stratigraphical unconformity between these beds and the underlying coal measures, nevertheless there is a very decided break in the fossil life, and the fauna and flora of the newer beds have been correlated with the Triassic system of Europe. These shales and sandstones have been named the Hawkesbury series, and have been subdivided as follows in descending order: -

(a) Wiannamatta Shales. Blue, red, and grey shales, with occasional beds of sandstone. These shales are used for the manufacture of bricks and tiles, and some have the qualities of fireclay.

(b) Hawkesbury Sandstones. Thick-bedded greyish- white freestones, used commonly about Sydney for building purposes.

(c) Narrabeen Shales. Beds of chocolate-coloured shales and greenish tuffs varying from a foot or so to about 1800 feet in thickness. These shales form a very definite and persistent horizon.

The Clarence River coal basin is composed of rocks closely resembling the Hawkesbury series, and they are regarded as contemporaneous, thus the -

(d) Upper Clarence shales may be the equivalents of the Wiannamitta shales.
(e) Clarence sandstones may be the equivalents of the Hawkesbury sandstones.
(f) Lower Clarence shalesmay be the equivalents of the Narrabeen shales.

It should be noted, however, that while the Clarence River series contains the fossil plants Tœniopteris daintreei and Thinnfeldia odontopteroides, the first-named has never been found in the Hawkesbury series, though Thinnfeldia is common in these rocks. It is possible, therefore, that the Clarence series may be newer than the Hawkesbury.

There are numerous seams of coal in the Clarence Measures, but they are too thin and their quality too inferior to be of commercial value. It is very probable, however, that these Triassic rocks may be underlain by the Permo-Carboniferous Coal Measures, which may mean a considerable addition to the coal resources of the State. The Clarence Coal Measures extend through Southern Queensland to the western flanks of the tableland of New South Wales. and dip thence under the north-western plains, forming the great artesian basin.

(xii.) **Jurassic System**. About 20 miles north-cast of Gulgong is a small lacustrine deposit of thin-bedded yellow shales containing plants and fish remains which are considered to be Jurassic. The deposit referred to lies unconformably upon massive beds of Hawkesbury sandstone: it is of small extent and is the only known representative of the Jurassic in the State. Amongst the fossil plants are Tœniopteris daintreei, Podozamites lanceolatus, Alethupteris australis, Thinnfeldia falcata, and Baiera bidens; the fish include Leptolepis gregarius, Archœomene robustus. Coccolepis, etc.

(xiii.) **Cretaceous System**. The Rolling Downs formation of Queensland, which has been classified as Lower Cretaceous, and which consists of a series of shales, limestones and sandstones, is not known to outcrop ab tile surface anywhere in New South Wales, but its characteristic fossils have been met with in wells at Yandama, in the Milparinka district, and a solid core from the Wallon bore, in the Moree district, shows that the drill penetrated about 1600 feet of Lower Cretaceous sediments there. It is possible, therefore, that these rocks underlie some considerable portion of the north-western plains.

The desert sandstones formation, which is believed to belong to the Upper Cretaceous epoch, is of very widespread occurrence over the north-western plains. There is a very marked stratigraphical unconformity between it and the Lower Cretaceous series, though there seems to be no practical distinction in regard to fossil life in the two formations. The most important fossils include - Isocrinus, Maccoyella. Pseudavicula, Belemnites, Ancycloceras. Crioceras, and Cimoliosaurus. The desert sandstone is generally horizontally bedded, and occurs as isolated hills and low ranges. Two varieties of rock are particularly noticeable, one being a greyish-white freestone, while the other is a vitreous rock of the character of porcellanite. Occasional beds of conglomerate occur, containing pebbles of quartz, agate, and chalcedony. and there is also a soft, flue-grained. siliceous rock having somewhat the appearance of kaolin. At White Cliffs, in the Wilcannia district, and at Lightning Ridge. north of Walgett, precious opal occurs in this rock, and extensive mining operations are carried on there.

(xiv.) **Tertiary System. (a) Eocene.** In the south-western portion of the State, along the course of the Lower Darling and Murray Rivers, there is a large area of marine calcareous sandstones. which have been classified as Eocene. In the Arumpo bore these beds have been proved to be at least 900 feet thick, the fossil Trigonia semiundulata being found at that depth.

At Tooraweenah, Warrumbungle Mountains, a lacustrine deposit, consisting of two series of

shales arid sandstones, occurs, containing Eocene plant remains. The two series of beds are separated by a flow of trachytic lava, and a similar lava covers the upper beds.

In New England (at Elsmore, Emmaville, etc.) Eocene leaves are found in fluviatile deposits (tin-bearing gravels) covered by basalt.

(b) Miocene. At Dalton near Gunnning. there is a lacustrine deposit of quartzite which has been classified as Miocene, on account of the plant remains found therein -

(c) Pliocene. Deep auriferous leads at (Gulgong and Forest Reefs have been found to contain Pliocene plant remains - seeds. etc. These deposits are mostly covered by basalt. Most of the Tertiary deposits are of lacustrine or fluviatile origin, and they are important chiefly on account of the alluvial gold and tin ore, as well as diamonds, contained in then).

(xv.) **Post-Tertiary.** Much of the alluvial gold, tin ore, and gems has been found in Post-Tertiary soils and gravels. These are for the most part shallow, and their contents have been easily recovered by the miners.

Pleistocene surface deposits cover great areas of the western plains, and are the means of obscuring the underlying geological formations and rendering prospecting operations difficult. At Mount Kosciusko there are evidences of much glaciation during Post-Tertiary times - striated boulders are very numerous, and glaciated pavements, roches moutonnees, and terminal and lateral moraines occur in a good state of preservation.

3. **Geology of Victoria.**[2] - The State of Victoria is of irregular shape, with the narrowest part to the east. Near the eastern end the Great Dividing Range enters, running south-westerly and westerly, being on the whole most rugged and of greatest altitude as it enters Victoria, i.e.. the general height falls as it runs westerly. On the whole also its southern faces are more steep than its northern, and as the Murray River is approached the character of the country is identical with that of the western plains of New South Wales.

(i.) **Geological Formations found in Victoria.** The following are the geological formations appearing in Victoria

SEDIMENTARY.

CAINOZOIC ... Recent; Post-Pliocene Pliocene - newer and older; Miocene, Eocene.
MESOZOIC ... Jurassic.
PALÆOZOIC ... Permo-Carboniferous; Carboniferous; Devonian; Silurian - Yeringhian and Melbournian; Ordovician - Upper and Lower Darriwill, Castlemaine. Bendigo. Lancefield zones; Cambrian - Heathcotian.

METAMORPHIC.

PALÆOZOIC ... Sehists.
ARCHÆAN ... Sehists and gneiss

IGNEOUS.

VOLCANIC ... Basic - Older and Newer Basalt; Acidic - Dacite, etc.
PLUTONIC ... Basic - Gabbro, etc.: Acidic - Granite, Syenite, Grano-diorite, etc.
DYKES ... Basic; Acid.

The metamorphic and sedimentary series will be referred to in detail in the inverse order of the

tabular statement.

(ii.) **Archæan System.** The Arehæan system includes gneiss schists. etc.

(a) Gneiss. In the vicinity of Barnawatha, Omeo, Bethanga. and Yackandandah there is an ancient system of rocks that are partly gneissic. White mica and garnets occur abundantly in them, and they are pierced by pegmatite. euritic, and other dykes. These rocks appear to be the most altered of the metamorphic series, and are more granitic in character than the schists of Yackandandah. At Cookimburra, Granya, and Bethanga, sulphides of Iead, copper, iron, zinc, etc., together with gold and silver, have been found associated with the gneissic rocks. in lodes and disseminated. The soil is of poor quality in places. but of rich character about Bethanga

(b) Schists. In many parts of Victoria schists have resulted from the alteration of the Silurian and Ordovician rocks caused by granite intrusions. Such schists may be seen at Maldon, south of Bendigo, Buxton, Beechworth, Omeo, Cassilis, etc. To the north of Yackandandah, however, there is large area of schist which appears to be pre-Ordovician. The schist is much contorted and crumpled, and is characterised by a black mica. It differs widely from the adjacent Ordovician rocks exposed at Hillsborough, etc.

Schists occur over a great portion of the east of the State, and also are found in the south-west, but, so far, the Archæan schists have not been separated from the less ancient series by mapping, although very distinct on the ground.

Economically the schists are important on account of the mineral lodes associated with them. Gold, silver, copper, zinc, lead, arsenic, etc., are found at Cassilis, for instance. The Yackandandah schists have not hitherto proved rich in valuable minerals, but the contact schists often carry auriferous lodes, as at Maldon, Stawell, etc. Limestones have not been observed in this series.

(iii.) **Palæozoic.** The Palæozoic rocks include the following, viz. - Cambrian, Ordovician, Silurian, Devonian. Carboniferous, and Permo-Carboniferous.

(a) Heathcotian. Cambrian (?) The Heathcotian rocks were first observed and separated from the Ordovician and Silurian beds in the neighbourhood of Heathcote, hence the name applied to them Professor Gregory. They consist of much altered and contorted cherty beds, full of thin, ramifying quartz veins, and of jaspers coloured red, green. yellow. etc.. associated with interbedded and intrusive diabases, serpentines, porphyrites, agglomerates and tuffs. Similar rocks occur in the Mount Camel Range, past Toolleen, as far as Lake Cooper; in Gippsland, at Mount Tara, Accommodation Creek, near Mount Deddick, Limestone Creek, Nowa Nowa at Green Hill and the Dog Rocks, near Geelong; and possibly at Waratah Bay, Mount Wellington, and near Wood’s Point. They are separated from the Ordovician rocks by a distinct unconformity.

Gold, silver, copper, lead. zinc, and iron ores have been found associated with this series. Iron ores may be mentioned at the Iron Mask mine, near Mount Tara, Nowa Nowa, and Dookie.

Distinct from the typical Heathcotian series, but probably Cambrian, are the phosphatic rocks of Mansfield. The phosphate is wavellite (phosphate of alumina). Barytes in veins and lodes is of common occurrence in the Heathcotian.

(b) Ordovician. Beds of this age outcrop at the surface over two considerable areas, one in the eastern part of the State and the other west of the meridian passing through Melbourne. They are composed of fine to coarse-grained sandstones, grits, slates, and shales, with rare thin beds of limestone and occasionally conglomerate, and are bent into a series of synclinal and anticlinal folds, and much faulted. The two Ordovician areas together cover about; one-fifth of the State. They are of vast thickness, but there is no reliable data on which to base an estimate.

The Ordovician is the gold-bearing formation of Victoria. Most of the gold, since its discovery 56 years ago, has been won from Quartz reefs in these rocks. or from alluvial deposits formed from their disintegration. The western area is the richer of the two, and includes such famous goldfields as Ballarat. Bendigo, Dunolly, Castlemaine. Maryborough. etc. The usual matrix of the gold is quartz.

Bendigo is famous for :its saddle reefs - quartz reefs that conform to the bedding in the arches of the anticlinal folds and less frequently in the synclinal folds. These occur one beneath the other, and have been worked from the surface down to a depth of 4250 feet. Along the anticlinals they have been traced for about 20 mi1es. A feature of this goldfield is the occurrence of basic dykes (limburgite) along the axis of the anticlines. The Berringa goldfield is marked by similar features.

Ballarat is remarkable for the vast quantity of gold which has been yielded from its deep and shallow alluvial deposits from the date of its discovery to the present time. Some of the nuggets were of great size.

A feature of the reef gold in Ballarat is that it occurs in connection with “indicators.” These indicators are certain “beds,” interlaminated with the usual slates, mudstones, sandstones, etc. When a quartz vein cuts across an indicator it is usually found to be enriched at the point of intersection. The other portions of the vein may be barren or very poor. The Tarnagulla district has long been famous for large gold nuggets, and has lately had public attention redirected to it by the Nick o’ Time and Poseidon rushes. Probably these masses of gold come from indicator lines, but so far they have only been found in alluvial deposits. It is reasonable to expect that similar masses of gold remain in their original matrix. Other localities for large nuggets are Moliagul, where the “Welcome Stranger" nugget (2315 ozs.) was found and sold at the local bank for £9436 16s. 8d.; Rheola, or Berlin rush, also is famous for its great nuggets.

Intrusions of granitic rocks are frequent in the Ordovician series, and they are also cut through by numerous acid and basic dykes.

(c) Ordovician Fossils. The following are amongst the typical fossils : - Upper Ordovician: **Stephanograptus gracilis, Dicellograptus elegans, Climacograptus bicornis. Glossegraptus hermani.** Lower Ordovician: **Dictyonemi pulchellum, Didymograptus caduceus, Tetragraptus serra, T. quadribrachiatus, Goniograptus macer, Clonograptus rigidus, Trigonograptus wilkinsoni, Phyllograptus typus, Siphonotreta maccoyi, Saccocaris tetragona, Rhinopterocaris maccoyi, Dinesus ida.**

(d) Silurian. The Silurian rocks occur between the two great Ordovician outcrops, and occupy about half the area of the latter. They are divided into the upper, or Yeringian, and the lower, or Melbournian, series. Members of the upper division occur in the extreme east of the State at Limestone Creek, and at Wombat Creek, Mitta Mitta River, and Walhalla.

The beds consist of varieties of sandstone, slate, mudstone. etc. Some of the sandstones are reddish or purple in colour, and in other respects differ from those of Ordovician age in general appearance. They are bent into folds, but not so sharply and evenly as those of Bendigo. Quartz veins are less frequent than in the Ordovician rocks, and auriferous quartz reefs are generally associated with dioritic dykes, and are often exceptionally rich, as at Wood’s Point, Walhalla, etc. Copper ore, associated with platinum, is found in a dioritic dyke at the Thomson R., near Walhalla. The goldflelds, however, are generally less extensive than those in the older rocks.

Limestones occur in lenticular patches of considerable extent in the upper part of the Silurian - series at Lilydale, near Mansfield, Mitta Mitta, Limestone Creek, etc. Lilydale supplies Melbourne with large quantities of lime.

(e) Silurian Fossils. Some of the characteristic fossils are given below - Upper series (Yeringian) : - **Favosites grandipora, Pleurodictyum megastomum, Chonetes robusta. Strophonella euglyphoidles, Leptæna rhomboidalis, Pentamerus australis, Atrypa reticularis, Panenka gippslandica, Concardium costatum, Cyclonema lilydalensis. Lower Series** (Melbournian) **Urasterella selwyn, Palæaster smythi, Protaster brisignoides, Botryocrinus longgibrachiatus, Siphonotreta australis, Chonetes melburnensis, Nucleospira australis, Hyolithes spryi, Cyphaspis spryi, Homalonotus harrisoni, Dalmanites meridianus, Pterygotus australis.**

(f) Devonian. The Devonian is divided into Upper, Middle and Lower. The principal mass of Devonian rocks lies between Briagolong and Mansfield. Sandstones, conglomerates, shales and limestones form the series. The sandstones are frequently red or purple and often mottled. The conglomerates are well developed near Mansfield, where they are several hundreds of feet thick, and are not folded. A remarkable feature of the conglomerates is the manner in which the pebbles are impressed into one another near Stockyard Creek. on the Dargo road, E. Gippsland. The Grampian Range, consisting of white, grey, red and purple sandstones, some conglomerate and a little shale with rocks of the Snowy River porphyry type, apparently interbedded at Hall's Gap, probably belongs to the Lower Devonian series, and is therefore too ancient to contain any coal seams.

Considerable areas of limestone of this age occur, the best known being at Buchan. The limestone tract here is 15 miles long and 6 miles wide. Caves have been known in this district for a number of years, and some discovered lately are said to rival the Jenolan caves in beauty and extent. Valuable marble occurs. At Bindi also a considerable area occurs.

The soil from the sandstones and conglomerates is very poor, but the shales and limestones are covered with, a very fertile soil.

(g) Devonian Fossils. The following are some typical fossils. Upper Devonian: - **Archæopteris howitti, Sphenopteris iguanensis, Cordaites australis.** Lower Devonian: - **Receptaculites australis, Favosites multitabulata, F. gotlandtca var. moonbiensis, Syringopora spelæanus, Chonetes australis, Spirifer yassensis, S. howitti, Phragmoceres subtrigonum, Asterolepis australis.**

(h) Carboniferous. The Devonian rocks appear to pass without an unconformity into the Carboniferous series. These beds consist of shales and sandstones of reddish colour, and contain abundant fish and plant remains. They are best known to the north of Mansfield.

(i) Carboniferous Fossils. Some Carboniferous fossils are **Lepidodendron australe, Gyracanthides murrayi, Acanthodes australis. Eupleurogmus cresswelli, Strepsodus decipiens, Ctenodus breviceps, Elonichthys sweeti, F. gibbus.**

(j) Permo-Carboniferous. The glacial conglomerates at Bacchus Marsh. Derrinal, Springhurst, Wooragee, Loddon Valley. and elsewhere are of very late Carboniferous or perhaps Permian age. The glacial conglomerates consist of pebbles and boulders, some rounded and grooved, and some still fairly angular, set in a fine tough clay matrix. The size of the boulders varies from several tons down to fine gravel. As a rule there is no stratification, but in places the boulder clay shews signs of rough bedding. This series appears to correspond with the Duyka conglomerate of South Africa.

Above the glacial series at Bacchus Marsh are thick bedded sandstones containing **gangamopteris, glossopteris,** etc.

The glacial beds yield a soil of good quality for grazing purposes.

(k) Permo-Carboniferous Fossils. Some characteristic fossils are as follows: - **Tæniopteris sweeeti, Gangemopteris obliqua, G. spatulata, G. angustifolia, G. cyclopteroides.**

(iv.) Mesozoic. So far as is known the Triassic and Cretaceous systems are not represented by any formations in Victoria. but the Jurassic system is of great importance, as it contains black coal measures.

(a) Jurassic. There are three considerable Jurassic areas exposed - those of South Gippsland, the Cape Otway District, and in the neighbourhood of Merino, in the extreme western part of the State. These three outcrops probably form part of a once continuous belt of similar rocks which is marked in the districts between them by Cainozoic sedimentary and volcanic rocks.

The rocks consist of felspathic sandstones, shales, and mudstones, while conglomerates occur along the coast near Kilcunda. Plant remains are common, and seams of black coal up to four feet thick are being worked in South Gippsland. These rocks are much disturbed and faulted, adding greatly to the difficulties of coal mining. Dykes and sills of basalt, as well as some old volcanic necks of early Cainozoic age penetrate these rocks.

(b) Jurassic Fossils. Amongst the characteristic fossils are : - **Coniopteris hymenophylloides var. australica. Cladophlebis denticulata var. australis, Sphenopteris ampla, Thinnfeldia odontopteroides, T. maccoyi, Tæniopteris spatulata and vars. daintreei and carruthersi, Ginkgo robusta, Baiera subgracilis, Podozamites barklyi, Palissyo australis, Brachyphyllum gippslandicum, Unio stirlingi.**

(v.) Cainozoic. The Cainozoic series, as represented in Victoria, is as follows: -

(a) Eocene. Beds of marls, clays, sandstones, and limestone of Eocene age are exposed along the littoral of Port Phillip at Geelong, Mornington, etc., and inland at Royal Park and along the Moorabool Valley. The limestone is used for building purposes, both as lime and as building stone, and for filters, and the marl at Mornington would form a valuable fertiliser for poor sandy soil.

(b) Miocene. Miocene clays, sands, conglomerates, etc., occur in the Moorabool Valley, near Morrison's, Melton, Altona Bay, Pitfield, in the La Trobe Valley, Cobungra, and at Feathertop, under the basalt of the Dargo high plains, etc. The brown coal beds are sometimes of enormous thickness. At Morwell a bore 1000 feet deep passed through 888 feet of brown coal. Many of the clays are valuable for pottery purposes, and they occur in very large quantities.

(c) Pliocene. The Pliocene period is represented in Victoria by sand dune formations and impure limestones near the coast, and by silt. sand, clay and gravel inland.

On the goldfields there are two distinct gravel formations, known as the Older and Newer Pliocene. The Older Pliocene gravels are generally com posed of well-rounded quartz pebbles, bound together by clay or ferruginous cementing material. They cap the hilltops or occur in deep leads at levels of 300 or 400 feet below the present surface. They are frequently highly auriferous. The old deep leads were the drifts in ancient river valleys, and have since been covered to great depths by more modern silts, or by flows of basalt. Valuable deposits of clay occur of this age.

The Newer Pliocene of the goldfields consists of some highly rounded pebbles derived from the Older Pliocene mixed with sub-angular and angular pebbles, bound together by red, purple and grey mottled clays and drift material. The gravels are often highly auriferous. The Newer Pliocene beds are found at a lower level than the older gravels which cap the hilltops.

Sands which may be of Pliocene age cover a large area in the Mallee district. Soil from the

Pliocene rocks is generally of poor quality.

(d) Post Pliocene. River terraces composed of red loam are found in the principal valleys as at Wangaratta, Carisbrook, etc. They contain Diprotodon remains indicating a fauna now extinct. These beds are most suitable for brickmaking, and yield a soil of good quality.

(e) Pleistocene Fossils : - Ostrea angasi, Myilus planulatus, Tellina deltoidalis, Natica conica, Vermetus novæhollandiæ, Pagrua unicolor, Sthenurus atlas, Macropus titan, Diprotodon longiceps, Phascolomys pliocenus, Sarcophus ursinus, Canis dingo.

(f) Recent. Under this heading come the present river drifts, the shifting sand dunes along parts of the coast, the deposits filling swamps such as Koo Wee-Rup and Carrum, the surface limestone found over wide areas in the Mallee, and the surface in process of formation. The soils range from the most fertile to the most barren.

(g) Fossils. Mr. Chapman[3] makes the following note : - "The Tertiaries are here grouped under their several local horizons. In the present condition of our knowledge of the Tertiary stratigraphy of the State, about the succession of which there are yet varieties of opinion, it is impracticable to exactly indicate the equivalence of the strata to the various series defined in European areas".

Some of the characteristic Tertiary fossils in descending order are: -

KALIMNAN. [4]

Balcontbe Bay Beds - Spondylostrobus smythi, Eucalyptus pluti, Plesicapperis prisca, Bathyactis beaumariensis, Glycimeris halli, Trigonie howitti, Zenatiopsis anqustata, Tylospira coronata, Voluta rnasoni, Cancellaria wannomensis, Cestracion caintozoicus, Oxyrrhina hastalis.

JANJUKIAN.

Coprosmæphyllum ovatum. Cyclammina complanata, Delfocyathus subrviola, Graphularia .senescens, Cassidulus australiæ, Terebratulina catinuliformis, Limopsis insolita, Spondylus gæderopoides, Spirulirostra curla, Carcharodon auriculatus, Squalodon wilkinsoni, Ziphinus geelongensis.

BALCOMBIAN.

Cinnamomum polymorphoides, Laurus werribeensis, Operculina cumplanata, Plectroninaia halli, Plachotrochus deltoideus, Magellania grandis, Arca celleporacæa, Crassatellites dennanti, Chama lamellifera, Cypræa eximia, Galeocerdo davisi, Lamna apiculata.

(vi.) **Plutonic.** A feature in the distribution of the granitic rocks is the manner in which the outcrops occur distributed over the whole State, except where the surface consists of Tertiary or Jurassic rocks which conceal the Plutonics. There are many varieties of the granitic rocks, such as granites, granodiorites, syenites, hornblende diorites. gabbros, etc. Auriferous quartz veins occur in the granodiorite rocks at Glen Wills, Mt. William and Warburton; tin lodes at Beechworth, Cudgewa and Koetong; copper at the Snowy River and in other parts of E. Gippsland; galena at Mt. Deddick and at Pine Mountain, Upper Murray. The soil derived from granitic rocks is generally of poor quality. The granodiorites yield a somewhat better soil than the other varieties.

(vii.) **Volcanic. (a) Diabases.** Interbedded lava flows, ash beds and agglomerates occur in the Heathcotian. which, as already mentioned, is a formation older than the Ordovician. These rocks

are well represented at Heathcote and in the Mt. Camel Range, at the Dog Rocks near Batesford, Green Hill near Geelong, etc. Soil of moderate quality.

(b) Snowy River Porphyries. These acid volcanic rocks of Lower Devonian age (?) are widely distributed in Eastern Gippsland, along the course of the Snowy River and in the Mitta Mitta Valley. With the lavas there is a great thick ness of ash and agglomerate, which contain bodes of gold, copper, and silver- lead ore. Extremely beautiful porphyries occur in these rocks. The soil is poor.

(c) Dacites. The age of the Dacite series is not settled. They form the mountains at Healesville and Warburton, Dandenong Range, Mt. Macedon, and part of the Strathbogie Ranges. No metallic lodes have been found associated with these rocks. The soil varies from a rich loam to a poor siliceous sand.

(d) Basalts. The oldest basalt known in the State is that described by Dr. Howitt as interbedded with the Upper Devonian at Snowy Bluff, but the important basalts are of Tertiary age.

The Older Basalt (Eocene to Pliocene) is found at Dargo High Plains, Gelantipy. Warragul. Narracan, the Mornington Peninsula, Phillip and French Islands, etc. The soil is fertile, but the area occupied is insignificant when compared with the area covered by the Newer Basalts.

The Newer Basalts (Pliocene to Recent) extend to the north-west and west of Melbourne for almost 200 miles. This volcanic series forms vast plains of lava flows and ashes with numerous scattered scoria cones in all stages of preservation. Excellent building stone and good road metal is furnished by these volcanic rocks.
The soil varies from a poor loam to dark brown and black clayey soil of marvellous fertility.

1. F. Chapman, Esquire. A.L.S., F.R.M.S., Palæontologist to the National Museum of Victoria, who has supplied the lists of typical fossils.
2. These are the sub-divisions of the Cainozoic accepted by Mr Chapman.

4. **Geology of Queensland** [5].From a geological point of veiw Queensland may be divided into two great parts, occupying nearly equal areas, but possessing very different physical features. One of these extends .along the eastern coast, from the New South Wales border northwards to the 12th parallel of latitude, has an average width of about 200 miles from east to west, and is well watered and timbered. To this division also belongs an area in the north-west portion of the State, viz., in the Burke district, extending from the extreme north-west southwards to Cloncurry and Boulia. The loftiest mountain ranges occur in this division, the remnants of what was once a high tableland, the highest peak, Bellenden Ker, attaining an elevation of 5150 feet.

This region consists of stratified rocks of different ages from the oldest palæozoic - the exact age of older rocks has not yet been determined - up to those of recent origin. There are also large areas of granites, porphyries partly of igneous and partly of metamorphic origin, as well as other intrusive and interbedded igneous rocks. It is in this division that most of the mineral wealth of the State exists.

The other large division, known as the Western Interior, consists almost entirely of the Lower Cretaceous rocks, overlaid unconformably in places by the Desert Sandstone, of which is of Upper Cretaceous Age.

This division, locally known as the Rolling Downs Formation, presents a vast area, in parts of almost treeless plains, with here and there clumps of "gidya" scrub.

The rainfall over this division, more especially in the south-west, is small. The river beds are generally dry. The want of water limits the use of some of the very best pastoral land in the State,

though this difficulty has been partially overcome by the tapping of the supplies of artesian water contained in the Lower Cretaceous Beds.

The rivers to the north of the high open downs, in latitude about 210 50' S., flow in a northerly direction into the Gulf of Carpentaria, while south of this they flow in a southerly, or south-westerly direction, into New South Wales.

(i.) **Geological Formations of Queensland.** The following table indicates the geological formations so far known as occurring in Queensland: -

QUATERNARY AND CAINOZOIC	Recent Alluvial, Raised Beaches, Post-Tertiary or Tertiary Alluvia, and Bone-Drifts
MESOZOIC	Upper Cretaceous - Upper Bowen Formation; Middle Bowen Formation; Blythesdale Braystone. Trias-Jura System - Upper Ipswich Formation; Lower Burrum Formation
PALÆOZOIC	Permo-Carboniferous - Upper Bowen Formation; Middle Bowen Formation; Lower Bowen Formation; Star Formation; Gympie Formation, Devonian - Middle Devioian Formation, Silurian - Silurian Formation. Age undetermined - Slates, Schists, and Quartzites, etc.

(ii.) **Plutonic and Metamorphic Rocks.** Large areas of granites, syenites, porphyries of both plutonic and metamorphic origin and of different ages, extend from the south to the north of the State.
In these a number of mineral areas are included, viz.: - The Charters Towers, the Croydon, Etheridge, Eidsvold, Normanby, Jimma goldfields; the Ravenswood gold and silver fields; Kangaroo Hills and Running Creek silver and tin fields; the Herberton and Annan, Bloomfield. and Stanthorpe tinfields; and the Mount Perry copper field.

(iii.) **Metamorphic Rocks.** These, embracing the slates, schists. etc., of undetermined age, are all older than the Burdekin Beds - Middle Devonian - and are all more or less metamorphosed. They consist of metamorphic granites, quartzites. slates, schists, gneisses, and shales. No fossils have up to the present been discovered in them, and their exact age has not yet been ascertained.

The principal mining areas in connection with these rocks are: - The Mckinlay, Cape River, Gilbert and Woolgar, Coen, Normanby, Clermont, and Peak Downs goldfields; and the Peak: Downs copper field.

(iv.) **Silurian.** A large region in the north-west part of the State, formerly included in the slates and schists, etc., of undetermined age, were transferred to the Silurian, the evidence as to the age of the rocks being determined by Mr. R. Etheridge, junr., from certain fossils found near the Cairns Range.[6,9]

The area mapped as Silurian extends from the south of Boulia to the extreme north-west, and from 20 miles cast of Cloncurry to the Western boundary of the State, but its boundary has not yet been accurately mapped.[7,9]

The principal mining areas are the Cloncurry, McKinley, and Leichhardt goldfields, the Cloncurry copper fields, and the Lawn Hills silver field. There are also the rich ironstone deposits of Mount

Leviathan, and of other hills in the neighbourhood of Cloncurry.[8,9]

(v.) **Middle Devonian** (Burdekin Formation). Rocks containing characteristic fossils of the Middle Devonian occur in various parts of the State. The principal area, and the one from which the formation takes its name, is on the Upper Burdekin, including the Fanning River, Burdekin Downs, and Broken River. Rocks of this age also occur at Chillagoe; Reid's Gap; on the Townsville-Charters Towers Railway; south of Clermont: at Raglan; and in the neighbourhood of Olsen's Caves, north of Rockhampton.

A doubtful area is shewn on the last addition of the State map in the extreme north-west, in the neighbourhood of Camooweal. The fossils occur in limestones, and consist almost entirely of corals, with a few Brachiopoda, and one Cephalopod. The most characteristic fossils are **Heliolites porosa, Pachypora meridionalis, Aulopora repens, Stromatopora,** and **Cystiphyllum.**

The Argentine silver field occurs in a series of slates and schists etc., supposed to belong to this formation.

(vi.) **The Permo-Carboniferous System.** The greater portion of the stratified rocks of the eastern portion of Queensland are included in this system.
The system, as hitherto classified, includes five formations, beginning from the oldest, viz: (1) Gympie Formation, (2) Star Formation, (3) Lower Bowen Formation. (4) Middle Bowen Formation, (5) Upper Bowen Formation.
A reclassification of these rocks may be found necessary; the following has been suggested: -

GYMPIE(?)	Marine Series; Basic and Acidic Intrusions.
LOWER BOWEN	Lower Marine and Volcanic Series; Lower Fresh-water Series; Upper Marine Series; Upper Fresh-water Series.
UPPER BOWEN	Marine Series; Fresh-water Series; Old Alluvial Deposits.

(a) **The Gympie Formation,** named after the type district (the Gympie goldfield), occupies large areas in the south-eastern, central, and north-eastern parts of the State, and consists chiefly of sandstones, grits, conglomerates, indurated shales, and limestones. These, in parts, have undergone considerable alteration. Bedded volcanic rocks are numerous, especially in the type district, as are also intrusive rocks. The strata generally dip at high angles of inclination.

This contains a very scant flora, represented by Calamites, Lepidodendron: but it has produced the largest fauna of any formation in Queensland, over 120 species having been described. The following genera are peculiar to it, viz.: -

Protozoa. - Lasiocladia.

Actinozoa. - Zaphrentis, Cyathophyllum, Cladochonus, Monticulipora.

Pelecypoda. - Pterinopecten, Mytilops, Parallelodon, Nucula, Pleurophorus, Astartella,Cypricardella, Eurydesma, Conocardium, Edmondia, Sanguinolites.

Gasteropoda. - Loxonema, Euomphalus, Pleurotomaria, Yvania, Luciella, Murchisonia, Bucania.

Blastoidea. - Mesoblatus, Granatocinus, Tricœlocrinus.
Echinoidea. - Archæocidaris.
Polyzoa. - Glauconome, Rhombopora, Myriolithes.
Brachiopoda. - Martinia, Athyris, Lingula.
Pteropoda. - Conularia.
Cephalopoda. - Nautilus, Gyroceras.
Pisces. - Deltodus?

Several gold and other mineral fields occur in the Gympie formation, amongst which may he mentioned : - The Gympie goldfield, Cania, Calliope, Norton, and other goldflelds in the Gladstone district; the goldfields of the Rockhampton district: the Warwick goldfields; Paradise, Hodgksnson, Mulgrave, and Palmer goldfields. Copper deposits at Glassford Creek, Gigoomgan, Gooroomgan, and Mount Coora; some mercury deposits at Kilkivan**;** and the Neerdie antimony mine.

(b) **The Star Formation.** The palæontological evidence for separating these beds from the Gympie Series is slight. They contain nineteen species peculiar to themselves, and twelve species common to both, but are, however, less, highly inclined than the Gympie Beds, and have been less disturbed and altered.

> They are best developed at the following places: - Near the junction of the Great and Little Star Rivers, from which they take their name; near Dotswood, Keelbottom Creek; in the neighbourhood of Harvest Home, Lornesleigh, and Mount McConnell Stations (near the latter the nearly complete remains of a fish of the genus Palæoniscus was found); and at Drummonds Range, where numerous scales and teeth of fish occur.
>
> The flora includes species of Calamites, Asterocalamites, Lepidodendron, Cyclostigma, Stigmaria, and Cordaites. The fauna is comparatively small when compared with that of the Gympie Beds, and includes the following with genera: -

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Crinoidea. - Actinocrinus.
Crustacea. - Beyrichia, Phillipsia.
Polyzoa. - Fenestella.
Brachiopoda. - Spirifera, Spiriferina, Retzia, Rhynchonella, Orthis, Strophomeana, Chonetes.
Gasteropoda. - Entolium, Euchondria, Nuculana.
Pteropoda. - Naticopsis, Porcellia.
Cephalopoda. - Orthocera.
Pisces. - Palæoniscus.

(c) **The Lower Bowen Formation.** This formation consists of a series of white and yellow sandstones, with beds of conglomerates, containing pebbles of quartzite and porphyry, derived from the metamorphic rocks in the vicinity: the lowest beds, seen near the heads of Pelican Creek, south-west of Bowen, consisting of volcanic agglomerates. It dips under the Trappean rocks of Toussaint, Mount Dinlin, and Mount Macedon.

> In another area, north of Mackay, the beds have undergone considerable alteration. So far no fossiliferous remains have been found therein.

(d) **The Middle Bowen Formation.** This series overlies the last without any marked unconformity. It consists of alternate sandstones, blue and grey shales, and impure arenaceous

ironstones, and extends from the type district on the Bowen River across the central railway between the Emerald and Duaringa, and for about 120 miles farther south up to the Dawson and Comet Rivers. The mapping out of these beds in detail on both sides of the central railway suggested the need for an alteration in the classification previously referred to.

> Seams of coal have been discovered therein, both north and south of the railway line, one thirty miles south of Duaringa being nine feet thick of perhaps the best coal for steam purposes in the State; it is anthracitic, containing almost 87 per cent. of fixed carbon. Several seams of coal - most of them of a burnt or coked nature - occur in the type district: this is due to the intrusion of sheets of trap rock.
>
> Although it contains a land flora in places the Middle Bowen is mainly marine. The flora include species of **Glossopteris** (which is very common), Sphenopteris, and a species of Conifer.
>
> The fauna consists of over fifty described species, of which the most characteristic fossils are : - **Strophalosia clarkei,** Eth.; **Strophalosia gerardi,** King; and **Derbyia senilis**, Phill., which, with species of **Productus, Spirifera**, and **Martinia** are very common.

(e) **The Upper Bowen Formation.** The Upper Bowen Beds are chiefly fresh water and contain but very small flora and fauna. The flora Includes **Phyllotheca australis, Sphenopteris lobifolia**, S. **flexuosa***,* S. **crebra, Glossopteris browniana**, G. **linearis**, and a species of a **Conifer**. The fauna includes **Derbyia senilis, Productus brachythœrus**, and a species of **Goniatites**.

> The rocks have a low angle of dip in the type district, and cover a large area to the south of these creeks. They contain numerous coal seams, including the Macarthur, Daintree, and Havilah seams, but most have been destroyed by the intrusion of sheets of dolerite.
>
> Beds of this formation occur west of Laura, on the Cooktown railway, on the Little River coalfield; at Hamilton, about twenty miles west of Cooktown; at Stewarts Creek, near Townsville, also further south near Mackay; and at Blair Athol, ten miles north-west of Clermont. Blair Athol is the only place where the coal seams of this formation are actually being worked; the coal is one of the best steam coals worked in the State.

(vii.) **Lower Trias-Jura** (the Burrum Formation). The Burrum Formation, the lowest member of Mesozoic rocks, extends along the coast from a point about 50 miles north of Bundaberg to south of Noosa Heads, and occupies an area of 3000 square miles.

Over the greater portion of this areas the coal measures are covered unconformably with sandstones, clays, and conglomerates of a more recent age, a fact to which is attributable the flat and barren nature of the country. The overlying rocks, 20 to 50 feet in thickness, lie horizontally or nearly so. Their exact age has not been determined, as no fossils have been found in them.

This formation consists of grey and brown sandstones, conglomerates, and grey and black shales, etc. The flora and fauna are both very scant. The former includes: - **Sphenopteris flabellifoila**, var. **erecta**, T. Woods; **Trichiomanites laxum**, T. Woods; **Thinnfeldia media,** T. Woods; **Tæniopteris daintreei**, McCoy; **Alethopteris australis,** Morris; **Podozamites kidstoni,** Eth. fil.; **Otozamites***,* sp. ind., and **Baiera bidens**, T. Woods. The fauna is represented **by Corbicula burrumensis**. Eth. fil., and **Rocellaria terra regina**, Eth. fil.

Seams of coal are known to occur in these measures in Littabella Creek, north of Bundaberg, to

near Noosa, in the southern portion of the field, and have been worked near the Burrum River in the neighbourhood of the townships of Howard and Torbanlea, situated about 20 and 15 miles respectively north and north-west of Maryborough.

In the Burrum River, just above the railway bridge, five seams of coal of payable thickness can be seen cropping out in the bank within a distance of half a mile, with a regular dip to the north-east at about 12 degrees.

(viii.) **Upper Trias-Jura** (the Ipswich Formation). The Ipswich Coal Measures cover an area of about 12,000 square miles in the south-eastern portion of the State, a small area occurring in the neighbourhood of Stanwell and Wycarbah, in the Rockhampton district; and another on Callide Creek, south-west of Gladstone, where there is one seam of over 30 feet in thickness of solid coal.

The rocks consist of the usual alternations of sandstones, conglomerates and shales, etc. In the neighbourhood of Brisbane the base of the measures is a volcanic ash, consisting of a felspathic matrix with blebs of quartz, and angular pebbles of schist and quartz. This stone is largely used for building purposes, as are also certain of the sandstones and freestones from this formation.

On the western portion of this area at Gowrie. Jimbour, and Clifton, the coal measures are on a higher horizon to those in the Brisbane and Ipswich district, from which they are separated by a thick mass of basalt.

The flora of the Ipswich Formation contains over eighty known species, five of which are common to the Burrum beds.

The fauna is represented by four species only, viz.: - **Estheria mangalensis**, Jones; **Mesostigmodera typica**, Eth. fil. and Oliff; **Unio ipsviciensis**, Eth. flu.: and **Unio eyrensis**.

Several seams occur in the Albert and Logan district, south of Brisbane, and thin coal has been met with close to Brisbane, but no mines have been opened up in either of these localities.

(ix.) **Lower Cretaceous formation** (the Rolling Downs Formation). The strata of this formation, covering nearly the whole of the western interior, have a very great sameness over this immense area - equal to over half of the whole State - and consist of shales, sandstones, conglomerates, and thin limestones. Thin beds of coal have been met with in boring.

A very porous bed of sandstone - the Blythesdale Braystone - has been traced from the neighbourhood of Texas, on the southern border of the State, to Normanton in the north of the Gulf of Carpentaria. This is the chief intake rock of the series from which the supply of artesian water is obtained.

The volume of flow of the many rivers that run across or along this sandstone greatly diminishes, shewing that it has absorbed the water. The efflux of the numerous bores, however, is very small when compared with the amount of water taken in by this rock and other porous beds that occur. It has been supposed that the water finds an outlet to the sea at the Great Australian Bight and at the Gulf of Carpentaria.

The Rolling Downs Formation has been classified under the general head of Lower Cretaceous, but it contains amongst its numerous fauna forms allied to the Oolite.

The fauna is represented by over 120 species. Ammonites and Belemnites make their appearance. Among the fish remains have been found the following species: - **Lamna daviesii**, Eth. fil.; **Lamna appendiculata, Agassiz;** a species of **Aspidorhynchus, Agassiz**; and

Belonostomus sweeti. Eth. fil. and A. S. Woods. There are also the following reptilian remains: - **Notochelone costata**, Owen; **Ichthyosauras australis**, McCoy; **Ichthyosaurus marathonensis**. Eth. fil.; **Plesiosaurus macrospondylus**, McCoy: **Plesiosaurus sutherlandi**, McCoy.

(x.) **Upper Cretaceous** (Desert Sandstone Formation). This formation at one time covered the greater portion of Queensland, but the work of denudation has left only isolated patches, or outliers, which overlie unconformably the older rocks. Some of these patches are of large extent, especially in the western districts, where they overlie and act as feeders to the Lower Cretaceous water-bearing beds.

The base of the Desert Sandstone, from 1000 to 1800 feet above the sea-level in the southern and central portions of the State, at Cape York Peninsula is nearly at that level.

The beds are always horizontal, or nearly so, and consist usually of very coarse sandstones (often false-bedded), coarse conglomerates, shales, and magnesite shales.

A series of rocks in the neighbourhood of Maryborough, overlying the Burrum Coal Measures, against which they have been faulted, have been included in this formation. They have produced a large number of fossils, some of which are allied to those from the Desert Sandstone at Croydon. Except at these places, the formation is almost barren of fossiliferous remains.

Glossopteris was discovered in rocks of this age at Betts Creek, near the Cape River goldfield, but had not before been discovered in Australia later than in the Permo-Carboniferous. **Glossopteris** was also found in the tableland between the Mitchell and the Walsh Rivers, and was consequently ascribed to the Carboniferous, though these rocks have since been found to be Upper Cretaceous. The genus makes its reappearance, therefore, in this formation, as it has not been detected in the formations intervening between this and the Permo-Carboniferous.

The fauna and flora are represented by thirty-five species, of which only the following eight species have been found outside the Maryborough rocks, and all of these, except the **Glossopteris**, are from Croydon: - **Didymosorus** (?) **gleichenioides,** Oldham and Morr.; **Glossopteris browniana,** Brong.; **Rhynchonella croydonensis,** sp. nov.; Os**trea**. sp. ind.; **Placuna,** sp. ind.; **Maccoyella barktyii**. var. **mariæburiensis**. Eth. fil.; **Tereda,** sp. ind.; **Siphonaria samwelli,** sp. nov.

The only mineral of commercial value from these beds is the opal, for which there is now a considerable demand. Its chief sources are Opalton, Mayne River, Opal Range, Jundah, Duck Creek, Nickaville, and Listowel Downs.

(xi.) **Tertiary**. The Tertiary deposits are very poorly represented in Queensland - in fact, with the exception of a few alluvial drifts and some raised beaches, no sedimentary deposits of this age are known.

There was undoubtedly great volcanic activity at this period, as is evidenced in many parts of the State by the outflows of basalt capping the Desert Sandstone.

(xii.) **Post-Tertiary and Recent**. This period is represented the bone-drifts on the Darling Downs; Peak Downs; at Maryvale Creek; and along the Burdekin River, etc. They have furnished numerous remains of living and extinct marsupials, such as **Diprotodon australis, Macropus titan, Macropus** ajax, and other species of the same genus; **Thylacoleo;** several species of **Phascolornys,** and **Nototherium,** etc.; a struthious bird **Dromornis,** and the remains of reptiles and fishes.

5. **Geology of South Australia**.[10] - In order to elucidate this indication of the principal geological formations of the State of South Australia, a short description of its physical geography is necessary.

A main range extends from Cape Jervis in the south, the opposite point of the main land to Kangaroo Island, to beyond Hergott Springs in the north, a distance of abotit 400 miles: branching from about 150 miles north of Adelaide to the New South Wales border in the vicinity of the Barrier Ranges, and from Beltana north-eastward to Mount Babbage. This area includes the Mount Lofty, Barossa, Flinders, Mount Nor' West and Willouran Ranges, and also smaller ones. The highest points are: Mount Lofty, 2327 feet; Mount Brown, near Port Augusta, 3200 feet; St. Mary's Peak, Wilpena, 3900 feet; and Benbonyathe Hill, near the Illinawortina Pound, 3476 feet.

The Tomkinson, Mann, and Musgrave Ranges extend in the north-west corner from the West Australian boundary eastward for over three degrees of longitude along and south of the 26th parallel of south latitude, the northern boundary of the State. The Gawler Ranges run from near Port Augusta westward for about 120 miles. Northward of these are the Warburton Ranges, isolated and of comparatively low elevation. Ranges of similar character are the Peake and Denison, west of Lake Eyre; and there are also detached areas in the vicinity of Port Lincoln and Franklin Harbour, on Eyre Peninsula. The remainder of the State consists of plain and undulating country, with occasional isolated low peaks.

The lakes, mainly large expanses of mud, are numerous and extensive, and occupy low-lying portions of the plain country; the principal ones are Lakes Eyre, North and South, Torrens, Gairdner, Frome and Blanche.

The Murray is the largest river. It enters the eastern boundary of the State in latitude 34º, runs eastward to Morgan, thence southward to its mouth at Encounter Bay, previously widening out into Lakes Alexandrina and Albert; this is the only navigable river in South Australia. The drainage from the eastern watershed of the main range, as far north as the Burra, runs into the Murray, from the western as far north as Port Augusta, into Gulfs St. Vincent and Spencer; further northward the eastern drainage is on to plains and into Lake Frome, and the western into Lake Torrens; north of latitude 30º drainage from all sides is into Like Eyre, the principal rivers being the Cooper and Diamantina entering from Queensland, the Finke from the MacDonnell Ranges, Northern Territory, the Alberga and the Hamilton from the Musgrave Ranges, and the Neales and others from the westward. From the Musgrave Ranges southward to the Great Australian Bight, and the west coast of Eyre Peninsula, there are no lines of drainage of any importance on the surface.

The coast-line presents roughly a sweep north-westward from Cape Northumberland in latitude 38º S., to Eucla latitude 31º 30' S., crossing 12 degrees of longitude (129º to 141º), deeply indented by two gulfs, St. Vincent's and Spencer's. Kangaroo Island, immediately south of St. Vincent's Gulf, is the largest island of the State, and there are numerous smaller islands, grouped and separate, in Spencer's Gulf, and on the west coast as far as Fowler's Bay.

From Eucla to the head of the Great Australian Bight, the coast-line consists of continuous cliffs from 200 to 300 feet high, forming the edge of the Nullarbor Plain plateau.

The various geological formations will be referred to in ascending order.

(i.) **Archæan (Metalliferous Rocks)**. Granite, gneiss, and crystalline metamorphic, hornblendic, micaceous and argillaceous rocks arc found at several places, but to a limited extent, to underline rocks containing Cambrian fossils; and in other places there considerable exposures of granitic and gneissic rock containing granitic dykes of later age, which may also be Pre-

Cambrian; these constitute the lower rock systems and may be classed as Archæan. Chief localities: southern portion of Yorke's Peninsula. North-East, north end of Main Range, Musgrave Range, etc.

(ii.) **Pre-Cambrian and Cambrian (Metalliferous Rocks)**. The Main Ranges from Cape Jervis to Mt. Babbage, the Ranges at Port Lincoln and Franklin Harbour, Kangaroo Island, the North-eastern (Olary) Ranges, Mt. North-west Ranges, the Peake and Dennison Ranges (near Lake Eyre), and isolated areas are composed of highly contorted, faulted, cleaved, jointed and metamorphosed beds of micaceous, hornblendic, and quartzose schists, sandstones, quartzites, argillites, clay slates, conglomerates, crystalline limestones and dolomites intruded into and intersected in places by igneous rocks consisting of granites, diorite, dolerite, gabbro, felspar, porphyry, felsite, etc. The Gawler Ranges are composed of granite and felspar-porphyry, the latter predominating, the Musgrave Ranges of granite, metamorphic and eruptive, and altered sedimentary rocks. Cambrian rocks containing fossils of undoubted Cambrian age, have been found
in dolomitic limestone beds at Normanville and Sellick's Hill, south of Adelaide, near Ardrossan, Yorke's Peninsula, near Gordon, Belton, Wirrealpa, Ajax Mine, and Ediacara in the far north, and east of Hawker. These beds occur in connection with those just mentioned, but owing to the intense plication, varying thickness, faulting and non persistence of individual beds and metamorphism of the whole series, their exact stratigraphic relationship can only be determined by exhaustive geological survey and mapping.

(a) Pre-Cambrian and Cambrian Fossils. These are as follows, viz: - **Ethmophyllum hindei, Coscinocyathus tatei, Microdiscus subsagittatus, Ptychoparia australis, Orthisina compta, Platyceras etheridgei, Stenotheca rugosa, Hyolithes communis, Protopharetra (?) scoulari, Olenellus pritchardi, Dolichometropis tatei, P. homwchini, Ambonychia macroptera, Ophileta sublangulata, Salterella planoconvexa, H. conularioides.**

(iii.) **Ordovician**. Beds of quartzite, sandstone, grit, shale, and conglomerate dipping at low angles and often horizontal occur on Kangaroo Island, in the neighbourhood of Port Augusta, along the western side of Lake Torrens, and on the Alberga River. No fossils have been found in them, but from the positions they occupy and their resemblance to the Ordovician fossiliferous rocks found south of the MacDonnell Ranges, they are probably of that age.

(iv.) **Jurassic**. This is represented by argillaceous, carbonaceous, and bituminous shale with thin bands of sandstone, limestone, ironstone, pyrites, etc., containing seams of coal. The best defined outcrop of this formation is at Leigh Creek, where a basin has been proved by boring to have an extreme depth of about 2000 feet of strata containing Jurassic fossils. In one bore at from 1496 to 1544 feet, over 47 feet of brown coal was passed through in one continuous bed, and small seams at intervals for 300 or 400 feet deeper. Characteristic fossils of the same age have been discovered at Ooroowillannie Swamp, near Kuntha Hill on Coopers Creek, and bituminous shale and coal similar to that of Leigh Creek at Lake Phillipson and other places in bores put down for artesian water. There is no distinct line of demarcation between this and the overlying Lower Cretaceous formation. It is probable that the sandstone, gravel, and conglomerate in which this water occurs is of Jurassic age.

(a) Fossils. The fossils observed are: - **Alethopteris australis, Macrotæniopteris winamattæ, Oleandridum (?) fluctuans, Podoxamites lanceolatus, Thinnfeldia odontopteroides, T. media, Unio eyrensis.**

(v.) **Lower Cretaceous**. These consist of gypseous clays, marls, argillaceous shales, and sandstones, with thin bands of limestone, ironstone, pyrites, etc., and sometimes thin seams of brown coal resting on sandstone and gravel conglomerate beds. This formation, with or without the underlying Jurassic beds, fills the vast artesian basin of which Lake Eyre is approximately the centre; from the north-east corner of the State it is continuous westward along the Queensland

border and to slightly beyond the 134th meridian, and southward along the boundaries of Queensland and New South Wales to latitude 30º S. Westward of Lake Eyre, its boundary has not yet been determined, but probably does not extend very far in that direction; it is bounded northward and southward by granite and other primary rocks.

The most western bore, viz., that at Lake Phillipson, has passed through a shale formation down to 3131 feet. The depth to which bores have been sunk in this area, and artesian water obtained, varies from a few feet in the vicinity of the outcrops of primary rocks to 4850 feet in that portion of the basin extending northward towards the Queensland border.

(a) Fossils. The fossils observed are : - **Lingula subovalis, Pecten socialis, Pseudavicula australis, P. anomala, Maccoyella barklyi, M. corbiensis, Lima randsi, Pinna australis, Mytilus rugocostatus, M. inflatus, M. linguloides, Nucula quadrata, Cytherea clarkei, C. woodwardiana, Leda elongata, Mya maccoyi, Natica variabilis, Cinulia hochstetteri, Belemites australis, B. canhami, Crioceras australe,** and others.

(vi.) **Mesozoic**. This is represented by argillaceous and arenaceous shales, grits, sandstones, quartzose sandstone, gravel, and conglomerate, with limestone and concretionary clay ironstone. The deposit, which is horizontal and undulatory, contains scattered pebbles and boulders of granite, quartzite, sandstone, etc. Some of these boulders are of great size, and denudation has led to their being scattered over the surface to a considerable extent. Bores have been sunk through the deposit to ascertain whether it contained coal, as from its general appearance and resemblance to carbonaceous rocks of the Cape Otway district, Victoria, which contain small seams of coal and are of Mesozoic age, it was thought that this might be the case. It may be noted that the Cape Otway beds also contain beds of pebble conglomerate, the pebbles consisting of granite, syenite, mica-schist, etc. The deposit is undoubtedly a glacial one. The greatest thickness proved by boring through these beds was 964 feet, at which depth clay slate of primary age was bottomed on. The area occupied by the deposit is considerable; the main body stretches across from Victor Harbour to Yankalilla, a distance of about twenty miles; it is of irregular shape, having a width in places of five miles, and lies in a trough between high ranges; its boundaries have not vet been completely defined, and probably underlies a portion of the Miocene Tertiary lying north and north-westward of Crozier's Hill and other places in the hundreds of Encounter Bay, Goolwa, and Waitpinga. Between YankaliIla and Second Valley, and at Cape Jervis there are beds of clay and boulder drift which may be of similar age; and these may, however, have been reconstructed from them or deposited during Miocene times. On Kangaroo Island, in the hundred of Menzies, there is a similar deposit, which consists of false-bedded horizontal and slightly-dipping beds of sandstone and grit, with pebble conglomerate layers on shale and sandy clay, containing concretionary masses of brown iron ore and ferruginous sandstone with pebbles, and overlaid unconformably by basalt; it appears to be an outlying area of the Yankalilla and Encounter Bay beds. No fossils have been found at any of these localities, but from the similarity of these beds to those of the Cape Otway district they may be provisionally classed as Mesozoic.

(vii.) **Lower Tertiary or Upper Cretaceous**. Chiefly in the north-eastern portion of the State there are large areas of stony downs and table-hill country where sheets and isolated cappings, as thin beds of sandstone, quartzite, conglomerate, jasper rock, porcelainised shale, etc., etc., overlie both the Lower Cretaceous and older rock formation, which are either of Lower Tertiary or Upper Cretaceous age. The beds are intermittent in character, and are scattered over an area extending from the end of the Musgrave Ranges eastward to the Queensland border, and southward to Lakes Frome, Torrens and Gairdner, and westward towards the West Australian border, in which direction they occur as small and widely-separated exposures.

(a) Principal Fossils. The principal fossils are: - **Mantellia babbagensis** and **Zamites ensiformis**.

(viii.) **Eocene**. The Eocene Formation is represented by polyzoal coral and shell limestone, chalky limestone with flints, fossiliferous clays, calcareous sandstone, and shale.

(a) **Coastal Localities**. On the Murray River, from Bookmark downward to Murray Bridge, good sections of these rocks overlaid by Miocene strata are exposed; the Nullarbor plain, extending from Eucla to Denial Bay, and forming sea cliffs from 200 to 300 feet high between the head of the Great Australian Bight and the West Australian border; the coasts of Yorkes Peninsula, Ports Willunga and Noarlunga, Kangaroo Island. and other places to a less extent.

(b) **Localities Inland**. Near Ardrossan, McLaren Vale, Mount Jagged; at these places the beds are elevated to a height varying approximatelv from 200 to 700 feet above sea level. On the Adelaide plains a bore at Croydon shewed a thickness of at least 2296 feet. The deepest bore sunk for water on the Nullarbor plain penetrated a thickness of 500 feet of crystalline limestone and white chalky limestone with flints, succeeded by shale, gravel, etc., to 1387, where it bottomed on granite.

(c) **Fossils**. The characteristic fossils are: - **Magellania insolita, M. pectoralis, Magasella deformis, Salenia tertiaria, Scutellina patella, Cassidulis lonqianus, Lovenia forbesi, Fibularia gregata, Oxyrhina woodsii, Aturia austrais, Voluta pagodoides, Fusis sculptilis, Turritella aldinqæ, Natica aldingensis, Dentalium mantelli, Dimya dissmilis, Lima bassii, Pecten consobrinus, Pecten aldinqensis, P. eyrei, P. flindersi, P. hochstetteri, Glycimeris cainozoica, Limopsis insolita, Chione cainozoica**.

(ix.) **Miocene**. This is represented by sand, clay, shale, loam, shell, limestone, sandstone grit, conglomerate, gravel, and boulder deposits. They fill the basins of ancient estuaries and old river beds, rising in the ranges and trending towards and into the sea, forming low cliffs along the coast and in its vicinity, and probably underlying newer formations at numerous places along the coast.

The oyster beds of the Murray Cliffs, Willunga, etc., are of this age.

(a) **Fossils**. The characteristic fossils are: - **Terebra crassa, Ancillaria oryeta, Latirus approximans, Marginella hordeacea, Murex anceps, Cominella subfilicea, Campanile triseriale, Semicassis subgranosa, Calyptræa crassa, Diastoma provisi, Heligmope dennanti, Natica subvarians, Ostrea sturtiana, Ostrea arenicola, Spondylus arenicola, Placunanomia ione, Pecten antiaustralis, P. palmipes, P. consobrinus, Lima jeffreysiana , Lithodomus brevis, Amussium lucens, Cucullæa corioensis, Mitylus submenkeanus, Cardita dennanti, Barbatia simulans, Meretrix sphericula. Trigonia acuticostata, Corbula ephamilla, Cardiun mediosulcatum, Lucina nuciformis, Dosinia grayii, Tellina lata, T. basedowi, Myadora corrugata, Panopæa orbita, Plesiastræa st. vincenti, Loripes simulans, Macropneustes decipiens**.

(x.) **Volcanic Rocks**. Basalt, dolerite, amygdaloid, lava, ash, etc., which have been derived from several points of eruption, cover limited areas in the south-eastern district in the vicinity of Mount Gambier and Millicent, and smaller areas in the hundred of Menzies, Kangaroo Island. Mount Gambier itself is composed of volcanic ash beds which at one time formed a portion of the walls of a crater. Mount Schanck is a perfect crater formed of beds of ash, scoria, etc. Other eruptive centres occur in the neighbourhood of Millicent. The basalt overlies beds of coralline limestone with flints of Tertiary age. The volcanic eruptions most probably took place at the same time as those in Victoria, where time basalt flows overlie Pliocene gold drifts. The Kangaroo Island basalt occurs as cappings in the hundred of Menzies, it rests on a formation similar to that of Yankalilla and Encounter Bay, the age of which has not yet been determined; its thickness is about 100 feet, and its geological age is most probably the same as that of Mount Gambier.

(xi.) **Post-Tertiary (Pleistocene)**. Sand, loam, concretionary limestone, clay, gravel, marl,

gypsum, salt, shell limestone, sandstone, limestone, conglomerate, gravel, and boulder drift - these constitute the surface formations over a large extent of the plain country and the alluvium of the creek and gullies running through and from the ranges into these plains, and as cappings to all rocks of greater age. Alluvial gold occurs in these deposits in many parts of the State, and has been worked for to a greater or less extent on the various goldfields which have been discovered in the main range from Cape Jervis northward, and on the isolated ranges west of Lake Eyre.

Fossil remains of large extinct mammals (marsupial), birds, reptiles, amphibians, and fishes have been found. These include: - **Marsupials**: Diprotodon, Nototherium , Phascolomys, Sarcoptilus. Palorchestes, Macropus, Thylacoleo. **Aves**: Genyornis (Newtoni), Phalacrocorax. **Reptilia**: Crocodilia - Pallimnarchus Polleus, larger than any living species, a freshwater species allied to C. Johnstoni, but larger. Chelonia (tortoise) - Megalania Prisca, a gigantic land lizard. (Localities: Warburton River, Cooper's Creek in vicinity of Lake Eyre). **Pisces**: Ceratodus Silurard, and other fishes. Thc localities are as just mentioned.

The chief localities of the mammals are Adelaide, Yankalilla, Millicent, Baldina. Bundey, Mundowdna, Booleroo Springs, Lake Callabonna. Warburton River. and Cooper’s Creek.

At Yankalilla and other places the remains of Diprotodon, etc., occur in soft spring deposits. At Lake Callabonna they are partially imbedded in the mud of the lake, in which they appear not to have been disturbed since their original deposition, and in other localities they occur in alluvium, either **in situ** or washed out by floods.

(xii.) **General**. Ice action is evidenced by glacial striæ on rocks of presumably Cambrian age, and on erratic boulders at Hallett's Cove and in the Inman River, and also by the occurrence of erratic boulders in the same district and on Yorke's Peninsula, Kangaroo Island, etc. There is no fossil evidence, but the deposit at Hallett's Cove underlies Miocene limestone, and may provisionally be regarded as of Mesozoic age. Erratic boulders are found strewn on the surface and imbedded in the Lower Cretaceous hales of the Central artesian basin.

6. **Geology of Western Australia.**[11] - The work of organising a systematic geological survey of Western Australia was commenced in 1896.

During the twelve years since thou the mining industry has attained such magnitude that attention has been concentrated upon examinations in more or less detail at and around important mining centres. Any general knowledge of its geology as a whole can consequently be gathered only from information gained whilst travelling from centre to centre taken with the observations of previous geologists.

In Western Australia an enormous area is covered by crystalline rocks, and only a limited area discloses the sedimentary series. The most recent formations repose directly upon the oldest; thus in the southern portion of the State, where the prevailing formations are crvstalline schists, they are fringed by deposits containing marine shells of existing types.

(a) Physical Features. The physical features of this State are in no way striking, the coast-line being generally very free from indentation and generally followed by low flat coastal plains at little elevation above the sea level, which again are followed by low ranges (the previous coast-line), whilst behind the latter are elevated plains, broken here and there by low ranges or isolated hills and areas of depression called "lakes." There are no mountains of an altitude known to exceed 3000 feet, whilst those rising from elevated plains do not as a rule present a striking appearance even locally). There are numerous watercourses but no flowing rivets, for these, owing to the gradual and uninterrupted fall of the land towards the coast, only run immediately after heavy rains, leaving only filled pools or waterholes behind.

The so-called lakes of the interior are, in reality, the chains of wind-planed salt flats lying along main valleys, and they are connected one with another, thus forming the drainage channels of this flat country, but as a rule the rainfall is so light in the interior that the water accumulated upon them surrounding country simply evaporates, leaving its salt burden behind.

The general character of the land surface presents that of one which period been subjected to erosion, in the course of which it is highly probable that wave action in a shallow sea has played an important part, since this appears to be the only satisfactory solution of the problem as to how the detrital matter was removed. Portions of this area (particularly the elevated one) have undoubtedly been land surface for a very considerable period, as their laterite cappings conclusively prove.

When we turn to the rocks this impression is further supported by the fact that the most modern stratified rocks as yet known here, after the Recent, are of Jurassic age; therefore we may safely conclude that the western portion of this continent has existed either as dry land or a group of islands in a shallow sea since the time at which an elevation took place in mid-Mesozoic times.

(i.) **Geological Formations**. The known geological formations of Western Australia are as follows: -

CRYSTALLLNE	Igneous origin; Metamorphic origin (Pre-Cambrian?).
PALÆOZOIC	Metamorphic origin (Pre-Cambrian?); Cambrian, Devonian, Lower Carboniferous and Permo-Carboniferous.
MESOZOIC	Jurassic.
RECENT	Superficial and marine deposits.
VOLCANIC	Sheets, flows and necks.

(ii.) **Crystalline Series**. The Crystalline rocks, which consist of granite, gneiss schist and greenstone, cover an estimated area of 650,000 square miles, or a total of two-thirds of the superficial extent of the State, and may be divided into three groups, the first of which comprises the granites, gneissic granites, and schists of the south-west division; the second, granites, gneissic granites and greenstones of the central and eastern portion of the State; and the third, granites, gneissic granites, schists and greenstones of sedimentary origin of Kimberley and the north-western districts.

(a) **First Group**. The first group is represented by a belt of gneissic granites and acidic schists, with intrusive granite and pegmatite veins, diorite dykes and quartz reefs, which occupy practically the whole of the south-western land division of this State; they occur in a belt that has a course a little west of north, extending from the south coast to the Murchison River, being about 200 miles in width at the south, extending from Point d'Entrecasteaux to doubtful Island Bay, whilst to the northward as it impinges upon the west coast it narrows down to 125 miles.

Upon the western side of this belt, these rocks form a bold escarpment to the seaward, called the Darling Ranges. This face is evidently a fault line, since rocks belonging to a much more modern period are exposed in places at their base, where the talus covering them has been removed or pierced by wells.

This range forms the edge of an interior tableland, but does not attain any considerable elevation; the highest point, Mount William, is said to be 3000 feet above the sea level.

The question as to whether these rocks are of sedimentary or igneous origin has not yet been determined, but the uniformity of their foliation and apparent bedding, with the occurrence of graphite, would almost favour the former. They have so far proved of economic value only at two points, viz.: Northhampton at the north, where lead and copper lodes are found associated with porphvritic diorite dykes, and at Greenbushes at the south, where tin deposits occur in pegmatic and griesen dykes. The diorite dykes which have been intruded into these rocks are generally of an aphanitic character, whilst the quartz reefs are large and often contain marcasite in considerable quantities, but, although generally carrying both gold and silver in small quantities, discoveries of a payable nature have not yet been made.

Upon the south coast, and also upon the eastern side of the Darling Range, a series of magmatic intrusions of granite are met, which upon the coast form bold bare headlands and islands of rounded and polished dome-like shapes or fantastical ruined forms, and this character is maintained by the island outcrops, which generally follow the lake margins between the Great Southern Railway line and the goldfields.

(b) **Second Group**. To the second group, which occupies the whole area of the eastern goldfields, very considerable interest attaches owing to its economic importance, and therefore, it has been more closely studied than any other series in this State, but, unfortunately, as yet this close attention has only been paid to main centres of production, whilst with regard to the balance but little is known.

The rocks of this region vary from that first mentioned in the occurrence of what appear to be lenticular magmatic intrusions of basic rocks probably of diabase origin, which have been altered by the action of paramorphism and hydration into amphibolites, hornblende and chloritic schists and epidote rock, whilst portions less altered still retain a massive form consisting of epidiorite or diorite. These magmatic intrusions are contained in a gneissic country of doubtful origin, whilst intrusive granite, often magmatic, has at a more recent period broken through them and is frequently met with at the contact of the gneisses with the greenstones. Except where purely local disturbances have taken place, the planes of foliation lie in a north-westerly direction, or parallel to the bug axis of the basic lenses, whilst the quartz reefs or lodes usually follow them, thus presenting a bedded appearance.

Basic dykes can be observed intersecting the gneissic rocks, whilst porphyritic and granite dykes are of common occurrence in the basic zone. It is probable, however, that the basic dykes also traverse the basic rocks, and the acidic the gneisses, but owing to their similarity in a weathered condition at the surface, it is difficult to determine their presence.

(c) **Third Group**. The third group includes reeks of undoubted sedimentary origin, in which the alteration is due in most cases to regional metamorphism owing to magmatic intrusions of igneous rock not necessarily always visible at the surface. These rocks are largely developed in the Kimberley and north-west districts, where the transition from undoubted sedimentary rocks of Palæozoic age can be traced into crystalline schists.

Although not crystalline, the slates. quartzites, and conglomerates of the same horizon, having undergone metamorphism, must necessarily be included in this group, and since both the crystalline and uncrystalline form the country rock of

metalliferous lodes, they are of equal economic interest, and in consequence have received considerable attention.

In the Kimberley district the two main rivers, the Fitzroy and the Ord, take their rise at the same locality, the former flowing in a north-westerly direction and the latter north, forming roughly a horseshoe-shaped valley, which follows the anticlinal axis caused by a granite intrusion, the beds in contact with which have been altered into schist, whilst following and overlying them upon either side, an ascending series of Palæozoic age is exposed.

These rocks are intersected by numerous granite and diorite dykes whilst a series of large auriferous quartz reefs and copper lodes occur both in the crystalline and uncrystalline portion of this series, following invariably the bedding planes of the rock.

In the north-west there is a greater complex of this series than in any other portion of the State, whilst they are of very considerable economic interest also since they contain a greater variety of metals and minerals than do the rocks of any other district. They have been very greatly disturbed and altered in places by intrusions of granite with pegmatite and diorite dykes, whilst at a more recent period the district has been the scene of very considerable volcanic activity, which has in all probability played an important part in the deposition of certain of the ores.

Under this section, the auriferous belt which includes both Norseman and Kalgoorlie has also been placed provisionally, but there exists very considerable doubt with regard to the soundness of this classification.

(iii.) **Palæozoic Series**. The Palæozoic Series, consisting of slates, Shales, quartzites, sandstones, conglomerates, and limestones from which fossils have been determined to be of Cambrian, Devonian, Lower Carboniferous and Permo-Carboniferous age, are most largely developed in the Kimberley district, but in it as yet no rocks newer than the Lower Carboniferous have been identified, although it is quite possible the extensive shale beds may be of the Upper or even Permo-Carboniferous age.

In this series some small lead and copper deposits have been discovered in the Napier Range, but with this exception they have not so far proved to be of any economic value in this district.

(a) **Devonian**. In the north-west district the Government Geologist assigns the Nullagine series provisionally to the Devonian period, the beds of which consist of sandstones, grits, and conglomerates, with interbedded volcanic flows or sheets. Of this series Interest attaches to the conglomerates, since they have proved to be auriferous in places, being very similar to the banket deposits of South Africa.

To the southward from the north-west coast this series of rocks is supposed to extend in a southerly direction for a considerable distance, probably as far as the Gascoyne River, forming a tableland through which the creeks have cut many cannon-like gorges, at the bottoms of which slates basic rocks, are exposed, whilst from the unconformable junction springs often flow.

(b) **Lower Carboniferous**. The Lower Carboniferous reeks are developed in the form of a long coastal belt, commencing a little north of the Ashburton River and extending southward across the Gascoyne and Wooramel Rivers, from which point they are lost until they outcrop again upon the Irwin River. It is, however, highly probable that they are continuous, their outcrops being hidden by superficial deposits.

This series north of the Wooramel consists of limestones, sandstones, shales, and conglomerates with a general dip to the westward, and it is from them that the large supplies of artesian water have recently been obtained at several points.

(c) **Fermo-Carboniferous**. The age of Permo-Carboniferous has been assigned by palæontologists to the rocks of three localities, viz., the Irwin River, Bullsbrook, a little north of Perth, and Collie, in the south-west. The rocks at the Irwin and the Collie consist of sandstones, grits, and pebble beds, with shales more or less micaceous and coal seams of a non-caking and poor quality, identical in composition with some of the Mesozoic coals of both Europe and America.

Some recent boring upon the Greenough River, a little to the north-ward of the Irwin River, has revealed beds of a similar coal. It is therefore possible that these are of greater extent than was supposed, and that they dip beneath the Jurassic beds which lie to the westward.

(iv) **Jurassic**. The Jurassic Series, which consists of sandstones, light-coloured claystones, grits, and limestones, occurs in the Northampton district, extending south to the Greenough River. In all probability it forms a continuous belt southward from this point, following the coast to Gingin, which is about 40 miles north of Perth, in which locality fossils of a similar age are said to have been obtained, but, since in the very greatly intervening country the surface is practically all sand, no definite statement with regard to it can be made at present.

(v.) **Recent**. The Recent deposits consist of raised beaches at various points around the southern and western coast and coralline limestones and sandstones, which sometimes contain fossils or casts of shells of existing types, thus proving this section of the coast to be rising.

(vi.) **Volcanic**. Until quite recently the volcanic series was considered to be only represented by a basaltic sheet in East Kimberley and an outcrop of the same rock at Bunbury in the south-west. Later investigations, however, prove that it is of considerable extent and importance.

These rocks evidently belong to two distinct periods, the one consisting principally of andesitic rocks and the more recent of basaltic. They both occur in the form of dykes, necks, sheets, and flows, and are often vesicular, whilst the andesites are sometimes amygdaloidal.

Basalt occurs as extensive flows, forming the Great Antrim Plateau in the East Kimberley district, which extends into the Northern Territory of South Australia, and is also met with at many points in West Kimberley, but this latter has not as yet been geologically mapped.

At Bunbury it occurs in sheet form, assuming the columnar structure upon the beach, whilst southward from this point outcrops are met with in the Lower Blackwood River, and at Black Point upon the coast.

The andesites are gradually proving to be of much more frequent occurrence than was supposed, since the cleaved hornblende andesites were often mistakeim for aphanitic ampibolites, into which they sometimes merge so imperceptibly that it is impossible to define a boundary. These rocks are largely developed in the north-west district, between the DeGrey River and the Ashburton River, whilst upon the Murchison goldfields they have been identified at Day Dawn, Cue, and Gabanintha, where they appear to have influenced the concentration of gold in the lodes.

(vii). **General**. A description of the geology of Western Australia would not be complete if the series of nondescript rocks called **laterites** were omitted, since they form one of the staple

surface formations of this State. These rocks are supposed to originate from the gradual weathering **in situ** of schists containing iron, which, whilst in solution, is drawn to the surface by capillary attraction and there deposited upon the evaporation of the water.

They are usually called ironstone gravel or conglomerates, and are found as capping to most of the hills upon the goldfields, also covering all the ranges in the south-western district. The rock varies greatly in both composition and character, the former being directly traceable to the parent rock from which it was derived, and the latter to the conditions under which it was formed. Nodular clay ironstone is by far its most common form, but it also often occurs in a massive state sometimes of considerable richness in iron, whilst at others it passes into a ferruginious sandstone.

No classification of the mineral veins has yet been determined upon, but typical examples of fault, dyke, shearing, discission, and shrinkage plane fissures, all of which possess one feature in common, no matter what class of ore is contained, which is that the matrix is quartz.

That the geological knowledge of Western Australia is at present very limited, is a natural consequence of the demand that the official staff shall give first attention to the study of economic problems. A considerable period must elapse before anything approaching a systematic survey can be undertaken.

7. **Geology of Tasmania.**[12] - Tasmania is a geological outlier of Eastern Australia. Its Pre-Cambrian and early Palæozoic history can be delineated only imperfectly. In Mesozoic times some connection existed with the Australian part of Gondwana land. In the early Tertiary it was separated from the adjacent island continent; subsequently the land connection was restored, to be again broken, since when it has remained an island. Dr. A. W. Howitt and Mr. C. Hedley have pointed out that the last land connection was between Wilson's Promontory in Victoria and Cape Portland in Tasmania, via Flinders Island and the Kent group, and that an elevation of from 200 to 300 feet would lay dry a tract of country between Victoria and Tasmania.

The rugged nature and the remoteness of the mountain fastnesses of the island have been great impediments to geological research. In spite, however, of the physical difficulties, it has been possible to fix the stratigraphy of a large portion of the State, though the lower Palæozoic strata need further study before they can be satisfactorily determined. As far a examination has proceeded the following systems can be recognised: -

i. PRE-CAMBRAIN.	iv. SILURIAN.	vii. TRIAS AND TRIAS-JURA.
ii. CAMBRIAN.	v. DEVONIAN.	viii. TERTIARY.
iii. ORDOVICIAN.	vi. PERMO-CARBONIFEROUS	ix. QUATERNARY.

(i). **Pre-Cambrian**. The diagnosis of the Pre-Cambrian must be accepted as provisional. It is probable that they belong to the Algonkian division of the group. Among them may be mentioned the quartzites and mica schists of the Port Davey districts. These are strongly developed in the south-west of the island as biotite and muscovite schists, greatly contorted, alternating with white saccharoidal quartzites, all striking north-west and south-west. High headlands of quartzites, which have resisted denudation, jut out on the south coast, with bare, snow white crests visible for many miles. Ores of copper, antimony, and lead occur in these schists. The contorted quartz schists and white quartzite of Rocky Cape, on the north-west coast, are also considered as Pre-Cambrians. Garnetiferous amphibolite in the Collingwood River valley, the amphibolite of the Rocky River, enclosing lenses of magmnetite with pyrrhotite and copper pyrites, and the zoisite-amphibolite of the Forth River, are also ascribed to the Pre-Cambrian group.

(ii.) **Cambrian**. This system is represented by friable, yellow sandstones, containing casts of Dikelocephalus, Orthis, Bellerophon, etc These occur at two widely-separated localities on nearly the same meridian, one being on Caroline Creek, between Railton and Latrobe, the other on the humboldt Divide and in the Florentine Valley. Mr. R. Etheridge reports that the fossils appear to be of Upper Cambrian age. The crystalline sandstones, quartzites, and conglomerate of which the Thumbs and Denison Ranges are composed are believed to be Cambrians.

(iii.) **Ordovician**. The slates and sandstones of the goldfields of Lefroy, Mount Victoria, Mathinna, Mangana, etc., in the northern and eastern parts of the island, are referred to this system, though few fossils of any stratigraphical value have been found. Their bearing is either east or west of north, and anticlinal axes are long and continuous. The gold quartz reefs which traverse them began to form apparently at the close of the Upper Silurian. Large and important mines have been opened on these reefs, and every geological consideration that can be adduced points to the permanency of the goldfields.

The conglomerates and sandstones at Beaconsfield, together with the blue limestones which prevail in that district at Blyths Creek and Winkleigh, as well as the Chudleigh and Railton limestones, may be provisionally regarded as of Ordovician age. The Blyth's Creek limestone has yielded imperfect casts of corals, and the Railton quarries contain remains of Actinoceras and other cephalopods.

A series of clay slates occurs between Zeehan and Mount Read, known as the Dundas slates, and believed to be of this age. Ill-preserved traces of graptolites have been noticed in them. These slates extend to Mount Read, Mount Black, and the Red Hills, and along their junction with intrusive quartz porphyry rocks (felsite, keratophyre, granophyre, porphyroid, etc.) large lenses of complex gold and silver bearing sulphidic ores of zinc, lead, and copper have been formed.

Another group of rocks at the base of the Ordovician is the Gordon River series of limestones, sandstones and slates. The limestone in this group is fossiliferous. The organic remains include **Favosites, Orthoceratts, Raphistoma, Orthis, Rhynchonella,Euomphalus, Murchisonia**, etc. The limestone reappears to the north-east of Mount Farrell in the bed of the Mackintosh River, a short distance above its junction with the Sophia River. East of the Valley of Rasselas these rocks occur again in the Florentine Valley and at the Junee.

(iv.) **Silurian**. The Silurians are strongly developed at Zeehan on the West Coast, at Middlesex, and Mount Claude, Heazlewood, and the Eldon Valley, Queen River, etc.

At Zeehan, conglomerates and tubicolar sandstone underlie the limestones, slates, and sandstones, which are intersected by the numerous galena-bearing lodes which have the ore for which this field is so well-known.

The fossils found in limestone and quartzite belong to the genera Hausmannia, Asaphus, Illænus, Cromus, Rhynchonella, Strophodonta, Lophospira, Murchisonia, Eunema, Tentaculites, and the beds are considered by Mr. R. Etheridge to be homotaxially equivalent to the lower portion of the Upper Silurian.

Similar tubicolar sandstone occurs near Bell Mount, Middlesex, and on the Five Mile Rise, and casts of Hausmannia (or Phacops), Rhynchonella, Orthis, and coral have been found.

Clay slates in the EIdon Valley containing fossil casts of Calymene, Orthis, Cardiola, are considered to belong to the Upper Silurian.

At the Heazlewood limestone and sandstone have yielded remains of Hausmannia, Cromus, Cornulites, Rhynchonella, Tentaculites, and Favosites.

Sandstones and limestones in the Queen River district have been identified as Silurian (Middle or Upper Silurian). These are west of Queenstown. Brachiopods, and trilobites have been found also on the east side of the Lyell Razorback, indicating a similar age for rocks on the LyeIl and Lyell Blocks mining properties there. The Queen River sandstones are charged with casts of Spirifera and Orthis.

Trilobite-hearing Silurian rocks also occur north of the Pieman River near the Wilson River.

In the Zeehan field the Silurian slates are largely accompanied by contemporaneous and intrusive sheets and dykes of veslcular melaphvre. The igneous rock corresponds very closely with the German spilite, an amygdaloidal diabase, sometimes called lime diabase.

Massive conglomerates crown most of the West Coast Mountains, the Dial Range on the North-west Coast, Mounts Roland, Claude, etc. These have generally been ascribed to the Devonian, but more recent data point to the commencement of the Silurian or even a still greater age as more probable.

The quartz-porphyries or felsites which form the backbone of the West Coast Range are the geographical axes of Mounts Darwin, Jukes, Huxley, Tyndal, Read, Murchison, and Farrell. They carry copper ore associated with lenses of hematite and magnetite, chloritic and felspathic copper-bearing schists, some of them, probably schistose porphyries, flank them and are enclosed in them. The felspathic schists of Mount Lyell belong to this group. Sufficient is not known of this geological formation to enable its age to be stated definitely.

Associated with the rocks of the Silurian system in the northern and western parts of the island is an extensive development of serpentine, the altered form of gabbro and its appendages, peridotite and pyroxenite. This rock is found at the Heazlewood, at Trial Harbour, in the Dundas district, in the Forth Valley, and near Beaconsfield. The difference of age between it and the Devonian granite is slight. Chronologically some of the granite is later.

(v.) **Devonian**. Granite occurs in a meridional line down the East Coast, extending from Finders Island to Maria Island. It forms Mt. Cameron, Mt. Stronach, the Blue Tier, Freycinet's Peninsula, and is exposed at Ben Lomond amid at the base of Mt. Arthur. Exposures are also seen at the Hampshire Hills, Granite Tor, Middlesex, the Magnet and Meredith Ranges, Heazlewood, etc. The quartz porphyry dykes at Mt. Bischoff, the tourmaline lodes at Mt. Black, and in the Dundas district, the stannite lodes and quartz-porphyry dykes at Zeehan, all denote a granite reservoir below a large portion of the mineral fields on the West Coast. No granite intrusion into Permo-Carboniferous strata has been observed. The normal granite is a dark mica one, but muscovite and lithia micas appear in the tin-bearing varieties. Tin-bearing lodes occur on Ben Lomond and Mt. Heemskirk, while on the Blue Tier floors or stocks of altered granite form huge tin ore bodies of low grade. Porphyry dykes at Mt. Bischoff have shed the vast accumulation of tin ores which has been mined by the Mt. Bischoff Co. for the last thirty-four years with wonderful success.

(vi.) **Permo-Carboniferous**. The base of the system is formed by glacial conglomerates, grits, micaceous sandstones and flagstones, well seen on Bruni and Maria Islands and elsewhere in Southern Tasmania. Fossiliferous mudstones and limestones form a lower division of the system, while the upper division comprises the Tasmanite shale and coal measures of the Mersey basin, with upper marine mudstones and shales in the Mersey basin and at Hobart, and the coal measure series of Mt. Cygnet and Southport. The characteristic fossil plants of the coal measures of this system are Glossopteris, Gangamopteris, Neggerathiopsis. The seams average from 1½ to 2 feet in thickness, and the analyses show from 36 to 42 per cent. fixed carbon, 41 to 48 per cent. gas, 2 to 9 per cent. ash, and 8 to 12 per cent. moisture. They are known as the lower coal measures of Tasmania.

South of Wynyard and at Barn Bluff, cannel coal or kerosene shale us met with. The Wynvard or Preolenna seam of this coal is in sandstone overlying fossiliferous mudstones, and assays up to 76 per cent., volatile matter. The Barn Bluff cannel coal has only been observed in loose blocks, supposed to have been distributed by glacier action.

At the chose of the system, or during Mesozoic times, a local intrusion of alkaline rocks, alkali and nepheline syenites, etc., occurred, traversing the Permo-Carboniferous strata south of Hobart, from Oyster Cove and Woodbridge on the Channel to the Huon River in a N.E.-S.W. line. Auriferous quartz and pyrites have been developed near the line of the contact of these igneous rocks with the Permo-Carboniferous sandstones and mudstones, and a good deal of free gold has been shed into the flats.

(vii.) **Mesozoic**. The fresh-water beds, which succeed the Upper Palæozoic, belong to the Mesozoic division, but cannot as yet be subdivided with certainty. The nearest approach to a subdivision would be as follows: but the reference to European equivalents is nothing more than an attempt at correlation homotaxially: -

(a) **Trias**	1. Variegated sandstones with remains of heterocercal fishes and amphibians.
	2. Sandstones and shahes with coal at Ida Bay.
(b) **Jura (or Rhætic)**	3. Upper coal measure sandstones.
(c) **Cretaceous**	4. Diabase in intrusive masses, sills and dykes.

The variegated sandstones occur at Knocklofty, the Domain, Ross, etc. Remains of Acrolepis have been found at Knocklofty and Tinderbox Bay. Bones of an amphibian (labyrinthodontine?) have been obtained from the Government House quarry in the Domain.

The upper sandstones are readily recognised by their soft felspathic nature: they are generally greenish-grey to yellowish-brown, sometimes white. They are widely distributed throughout Eastern and South-eastern Tasmania, and occur also in the extreme south. They are largely interrupted by intrusions of diabase. Tlsey flank the central, eastern and western tiers, and fringe isolated mountains, *e.g*., Mt. Nicholas, Mt. Victoria, Ben Lomond, Ben Nevis, Mt. Dundas, Cradle Mountain, etc. From Fingal and Mt. Nicholas they extend on the outskirts of the diabase ranges southward to Seymour, Bicheno, Llandaff, Spring Bay, and all ever South-eastern and a large part of Southern Tasmania.

These measures enclose the coal seams, averaging from 4 to 12 feet, which are worked at the Mount Nicholas, Cornwall, York Plains, and Sandfly collieries. The analyses of this coal range from 53 to 60 per cent. fixed carbon, 23 to 31 per cent. volatile matter, 9 to 16 per cent. ash, 2 to 4 per cent. moisture, and the coal is not a coking one. A sub-antracitic coal is raised at York Plains, and at the Sandfly mine a seam of anthracite occurs containing 80 per cent. fixed carbon and 8 per cent, volatile matter.

The fossil flora from these measures must be regarded as characteristic for the Mesozoic. The lust includes Thinnfeldia, Pecopteris, Tæniopteris, Sphenopteris, Alethopteris, etc.

The diabasic intrusions cut up the coal measure areas unto different basins and cover large portions of the Central, Eastern and Southern districts.

(viii.) **Tertiary**. A great stratigraphic break exists between the Mesozoic and the succeeding strata. This Tertiary system cannot be subdivided as in Europe. The two divisions, Palæogene and Neogene, are adopted in Tasmania. According to this arrangement, the subdivisions are as

follows: -

(a) **Neogene** (= approximately to Pliocene). Under this head would fall various river terraces and estuarine deposits.
(b) Palæogene (= Eocene to Miocene).
3. Basalt lavas.
2. Fluviatile and lacustrine clays and sands, tin ore drifts, and deep leads.
1. Fossiliferous marine beds it Wynyard (= Eocene).

The marine fossiliferous beds at Wynyard are covered with the basalt which, generally throughout the island, appears to separate the Lower from the Upper Tertiaries. The extensive lacustrine deposits within the watershed of the Tamar cover an area of 600 square miles, and embrace widely-spread pre-basaltic or Palæogene clays and sands, which form a series 900 to 1000 feet thick. Such sediments with fossil leaves of Europeans genera occur at Launceston, Dilston, Windermere, Beaconsfield, Waratah, Strahan, St. Helens, Burnie, and on the Derwent. In the north-east and east, the sub-basaltic gravels are worked on a large scale for tin ore, and yield most of the alluvial tin of the State.

At the close of the Palæogene a great outpouring of basaltic lava took place, and this rock is very general throughout the Island, though rarer on the West Coast.

The rock is usually olivine basalt, but nepheline basalt occurs on the Shannon Tier, and at Sandy Bay, Hobart.

The Neogene valley terraces can only be distinguished from the earlier Tertiaries by position and lithological characters. Some of the gravel drifts of the Derwent, of the Longford plains, and in the neighbourhood of Launceston, belong to this subdivision. The close of the Tertiary, or the beginning of the Quaternary, witnessed a glacier epoch in the west and centre of the island. The highlands round Barn Bluff, Mounts Tyndal, Lyell, Sedgwick, Jukes, Darwin, etc., and the western edge of the great central plateau abound with tarns, ice-scratched stones, and moraines. No proof of glacier conditions in this period in the eastern part of the island has been adduced yet.

Tin and geld ores are the most important products of the deposits of the Tertiary system. They are won from the alluvial gravels and leads of the period. The sands in the Savage River and other tributaries of the Pieman and Huskisson have been worked for osmiridium. Zircon sand, near Table Cape, has also been exploited. Tertiary clays are used largely for brick-making and pottery, the gravels for road-making. Lignites exist, but are not yet industrially important. Though there has been great volcanic activity, there are no signs of Tertiary metalliferous veins.

(ix.) Quaternary. These deposits may be classed as follows: -

(a) Recent.
3. River alluvium and sand dunes.
2. Raised beaches and helicidæ sandstone.
(b) Pleistocene.
1. River drifts.

The later terrace drifts in the valleys of existing rivers are referred to the Pleistocene. Sand dunes, consolidated to shelly sandstones, occur on Cape Barren, Badger, Kangaroo and other islands in Bass Straits, containing shells of Helix, Succinea, etc. These sandstones sometimes overlie a raised beach. The raised beaches on the North and South Coasts indicate elevation within the Recent period.

(x.) **Ore Deposition.** The period during which the deposition of metallifereus ores was most active was the interval between the Upper Silurian and the Permo-Carboniferous. Ore deposition

has been associated principally with the consolidation of the gabbroid and granitic masses. Nickel sulphide and osmiridium ewe their origin to the serpentine at the Heazlewood, Trial Harbour, and Dundas. On the other hand the granite magma is responsible for the lodes of silver lead all over the island, whether these pierce quartz porphyry as at the Devon and Mount Tyndal, slate, sandstone and limestone as it Zeehan, or ultra basic dyke rock as at the Magnet. The pyritic lead, zinc, or copper ores of the West Coast Range (Mount LyelI, Mount Read, Mount Black, etc.) are also most probably due to the action of the acid magma. Tin and wolfram ores are naturally referred to as the same source, and the gold quartz reefs of the Ordovician strata must be regarded as the result of the expiring effort of the cooling magma to get rid of its surplus available silica. A few veins or barren quartz occur in the Permo-Carboniferous strata, but beyond the exceptional case of the alkali porphyries at Port Cygnet, the chapter of metal-bearing lode action closed, as it began, with the Devonian period. Within that period, therefore, were accumulated the great store of mineral which the mining industry of Tasmania is now drawing upon. The mines of gold, silver, lead, copper, and tin, rank high among the famous mines of the world. Her mineral wealth may, in fact, be considered remarkable, when despite the small area of the island (26,000 square miles) the value of the mineral produced for the year ending 31st December, 1907, amounted to £2,277,159. The industry is thriving, is on a sound and established basis, and with the care which it receives, it may with confidence be expected to continue a highly important asset of the State for a quite indefinite period of time.

Footnotes:

1. This article is contributed by E. F. Pittman. Esquire, .A.R.S.M.. Under Secretary for Mines, New South Wales, Government Geologist of New South Wales, sometime Lecturer. etc., on Mining University of Sydney.
2. This article was contributed by E.J. Dunn, Esquire, F.G.S., Director of the Geological Survey of Victoria.
3. F. Chapman Esquire, A.L.S., F.R.M.S., Palæontologist to the National Museum of Victoria.
4. These are the sub-divisions of the Cainozic accepted by Mr. Chapman.
5. This article is slightly condensed from one by W.H.Rand, Esquire, A.R.S.M., F.G.S., Government Geologist of Queensland.
6. These were identified as follows: - (6) Orthoceratites, sp. ind.;
7. (7) Actinoceras (beaded siphuncle), sp. ind.;
8. (8) Univlve and bivalve (casts and impressions). These are intersting, as the first Silurian fossils found in Queensland.
9. See map of Queensland of 1809.
10. This article is contributed by H. Y. L. Brown, Esquire, F.G.S., Government Geologist of South Australia.
11. In the absence of A. Gibb Maitland, Esquire. F.G.S., etc., Government Geologist of Western Australia, this article was contributed by Harry P Woodward, Esquire, F.G.S., Assoc. M. Inst. C.E., Assistant Government Geologist of that State.
12. This article is contributed by H. W. Twelvetrees, Esquire, Government Geologist and Chief Inspector of Mines of the State of Tasmania.
13.
